

# Problems and Results in Barley Breeding



By H. V. Harlan, *Principal Agronomist*, and M. L. Martini, *Assistant Botanist*, Division of Cereal Crops and Diseases, Bureau of Plant Industry

**B**ARLEY fields are found widely scattered over the more temperate parts of the world. They also form a picturesque part of the agricultural frontier. Barley fields occur in Europe, north of the Arctic Circle, and also on the plains of India. Barley is grown on the high plateaus of Tibet. It climbs still higher up the slopes of Mount Everest, where one form protects itself from the wind by a recurved stalk that places the heads almost on the ground. Barley is found fringing the oases of the Sahara or growing beneath the date trees. It is the crop that is grown highest up on the mountain peaks of Ethiopia, where pools of water are often frozen over beside the growing grain, and it is cultivated in the lower delta of the Nile, where brackish water lies 18 inches below the surface.

Arab farmers are seeding barley on the dry hills of Mariout along the Mediterranean in northwestern Egypt where the rainfall is but 8 inches, just as they were in the days of Rome, and Chinese peasants are growing age-old varieties in their western hills. Barley is cultivated by Hindus, Turks, and Japanese. It is grown by Russians, Berbers, and western Europeans. It is one of the grain crops of a hundred peoples throughout the temperate world. It is man's most dependable cereal where alkali, frost, or drought are to be encountered. Its greatest acreage, however, is found under more favorable conditions. It grows particularly well where the ripening season is long and cool. This is especially true in sections where the rainfall is high, for while it will stand much heat in the absence of humidity, it does not mature so well in hot humid weather. It grows better with moderate rather than excessive rainfall, better on well-drained lands than on water-logged or sandy ones.

Favorable conditions are found in our Northern and Western States. Our most extensive acreage is in the north Mississippi Valley and in California.

## *The Position of Barley in American Agriculture and the Chief Problems of the Breeders*

**I**N THE United States, barley is most widely grown in the Northern and Western States. On well-drained soils not too sandy in character it produces more feed per acre than other small grains in these States. Much of the barley acreage is not in competition with corn, since it is grown north and west of the region where corn is the dominant crop. The trends for the past few years indicate a normal barley crop of around 300,000,000 bushels. The crops of the 2 years 1933 and 1934 are not a true measure of our production, for drought affected much of the barley area in both years.

Barley has several natural advantages as a farm crop in the regions to which it is adapted. It produces a high yield per acre. It is early, and often escapes drought and usually is mature before rust becomes dangerous. It can be seeded later than other grains with better chances of success. It grows vigorously and usually smothers weeds.

Barley fits well into the agriculture of the north Mississippi Valley. The brewing demand affords a nearby cash market for the better qualities. The dairy industry uses a large amount of barley for feed. In those areas where the period available for spring work is short, it insures a fair production of feed on late-seeded ground. In the West it is the dominant feed grain. It grows well in such places as the interior valley of California and on the irrigated lands of the Rocky Mountain region. The importance of winter barley is increasing in the Southern States. Here it affords winter pasture when seeded for this purpose and the yield is fair where the crop is grown for grain. The barley acreage is probably smaller than it should be. Little of the present acreage devoted to barley could be used for any other small-grain crop without loss.

### REGIONAL PROBLEMS IN BARLEY BREEDING

The major objectives of barley breeders are higher yield, malting quality, and convenience in handling. To attain these objectives many factors must be considered. Low yield in one place may be due to lodging; in another to disease. Earliness may be important in one place and undesirable in another. Nonshattering varieties are essential where combine harvesters are used. Smooth-awned ones are desired by most farmers who harvest with a grain binder or use the crop for hay. A few farmers need varieties with special qualities. One may wish a variety that stools little, so that it will not grow too thickly, for use as a nurse crop, while another may wish one especially suitable for growing in high cold valleys where summer freezes are common. In other words, the problems of the various barley-growing sections must be studied separately, and these regional problems will be broadly surveyed here. We must also realize that in the future the requirements will become more and more specific, and these the plant breeder must meet.

## Upper Mississippi Valley

In the Upper Mississippi Valley, much barley is grown primarily for malting purposes. When a maltster finds undesirable fungi spreading in his bins, or when a brewer has to start the pumps on a mass of unfilterable material in the mash tub, what does it mean? It traces back to the mistake of a buyer who this year is buying malting barley perhaps in northern Illinois, next year perhaps in South Dakota, searching always for the best for his purpose. Why is he forced to search? The reason lies mostly in the American climate that is favorable in varying localities in different years. In one season good barley can be grown well in the Corn Belt; in another, scab spreads rapidly on barley grown in the south on cornland and even finds conditions favorable far north, and then the maltster must be careful. In some years there is a long cool ripening period and the barley matures well and brewing supplies are plentiful. In other years drought or heat stops the maturing too soon, or storms lodge the crop and cause an interruption in the growth of many spikes. As a result, steely barley is in sight, and difficulty in brewing is sure to follow.

Such are the conditions that must be met. The plant breeders' problem is to produce varieties resistant to scab, that will lodge less easily, and that are as drought-resistant as is possible within the requirements of high yield in normal years.

Moreover, the farms of this section have become accustomed to smooth-awned barleys. In the future they will insist on new varieties being smooth. Over most of the area they will demand a malting variety. To most growers the chance of securing barley of premium grade for malting is sufficient to justify this choice. Indeed, it may be possible throughout the area to utilize malting varieties which will produce yields equal to those of the best feed varieties. That question is in the hands of the plant breeder. However, there is always a certain percentage of farmers who know at planting time that they will feed their whole crop. If feed varieties are available which are more satisfactory for their purpose than the malting sorts, some farmers will grow them.

## Upper Plains

In the Dakotas and Montana the problem is complicated. A smaller percentage of the crop is likely to be used by the maltsters. Much of it is seeded on weedy land. The highest yields in many sections are produced by varieties not wanted by the maltsters. Droughts are frequent in the western Plains, and the farmer must choose between higher yield on the one hand and the chance of getting a market premium on the other. In the drier sections good yields in good years should be combined with the maximum insurance of some yield in bad years. The problems of the plant breeder are to combine quality and yield if possible, and, if not, to produce easily recognized varieties for the two purposes.

In the drier sections the best yields will be secured from early varieties, possibly from early varieties not entirely exserted from the boot; that is, the stalk ceases to elongate before the head is freed from the upper leaf and, therefore, the spike remains partially enclosed by it. But such varieties will not produce the highest yields in the better years, and at present there seems no way of combining the two

qualities. Most of the barley is certain to be used for feed in the average year, and the number of varieties under cultivation need not be as limited as in the regions where most of the barley purchased is used for malting. Wherever local conditions are diverse, a larger number of varieties are necessary to secure the maximum usefulness in an area. There are localities where the very earliest sorts are needed. There is another area in western North Dakota which appears to be better adapted to the production of two-rowed<sup>1</sup> sorts and one of the best varieties at present in Montana and parts of Wyoming is a two-rowed one.

### Middle Plains

The only area in the central or southern Plains producing barley for market is centered about northwestern Kansas. This area is a peculiar one. The grain ripens in clear bright weather, usually with very little rain. The harvested grain has the general appearance of western barley. This is due not only to the ripening conditions but also to the fact that one of the common types, Stavropol, is very similar to the barleys grown on the west coast. Barleys of the Manchuria-Oderbrucker group are also grown. They, too, of course, are brighter than when grown in the more humid districts. In good years much of the crop may be sold to maltsters. The better lots of both Stavropol and Manchuria are sold for malting, but usually with preferences expressed by different buyers or even on different markets. Unless yield can be combined with quality and these with a type familiar to and desired by the malting trade, the situation must be met by the use of two or three varieties. The proportion of feed and malting types will vary with the premiums existing the previous season. Elsewhere in the middle and southern Plains where spring barley is grown, earliness and drought resistance are important.

### Rocky Mountain Region

In the high mountain regions almost all varieties do well where irrigation water is available or where the natural rainfall is sufficient for the needs of the crops. In the hotter and more windy sections certain types, even though they grow well, cannot be used commercially as they shatter badly. In the cooler, better protected sections many varieties do well and are grown. Despite the fact that most barleys grow well, the breeding problems are very complex. Malting quality under irrigation is easily obtained, but feed in many sections is at such a premium that the feed demand is greater than the malting demand. Again, the region is made up of an endless number of units, each differing slightly from its neighbors in climate and economy, and often in farming practice. Over most of the world each mountain valley has eventually become a reservoir of safe keeping for a variety particularly adapted to that valley. Possibly that is the ultimate solution in America. At present the main problems are yield, resistance to shattering, resistance to lodging, and in some of the very cold valleys, resistance to summer frosts.

<sup>1</sup> Six-rowed barleys have three kernels at each node of the rachis and, since the nodes alternate, there result three rows on each side of the spike. Two-rowed barleys bear a single kernel at each node or single rows on each side of the spike.



FIGURE 1.—A barley nursery at Aberdeen, Idaho, where more than a thousand barleys are grown in short rows.

### Pacific Coast

The European brewing market has been of great importance to west-coast barley producers for many years. This is particularly true of the California farmers. The use of varieties desired by the maltsters is essential. Shattering is one of the very important factors of yield. Two or three windy days in succession often have reduced the harvestable grain by half. Sometimes the winter rains come late. Seeding later than mid-January is often unsatisfactory unless quick-maturing varieties are used. Aside from the interior valley, there are many localities in California where barley is grown, and they differ from one another in their requirements. Situations like the Salinas Valley have long cool ripening seasons, and others like the Imperial Valley are characterized by early intense heat. The plant breeder has much to consider. His problems are not lessened in Oregon and Washington. The Willamette, the Klamath, and the Palouse are vastly different from one another. In the drier area of eastern Oregon and Washington, lodging is often caused by the failure of secondary roots to develop.

### Southern Winter Barley Region

Winter barley is grown from Maryland to central Georgia and west to New Mexico. The total acreage is small. The situation is very complicated. True winter varieties are grown along the northern edge of the winter barley region. These extend on the higher lands into Georgia. Along the Coastal Plain and in the southern half of the region through Texas and New Mexico, varieties with less winter habit, or none, are often found. In Southern Arizona and California, spring varieties are seeded in the fall or winter for the entire crop. In Southwestern Kansas and adjacent areas, spring and winter seedings overlap.

The problems are endless. Greater winter hardiness is badly needed in Maryland, the Piedmont, southern Ohio, Oklahoma, north Texas, and Kansas. Yet the qualities that make for cold resistance are not the same in western Oklahoma as they are in Maryland or southern Ohio. Farmers who grow little barley object to rough awns. Throughout the South, smooth-awned or high-yielding hooded sorts are in demand. Yield will probably best be secured from the smooth-awned sorts. Winter dormancy in some localities needs to be separated from winter hardiness, as dormancy delays growth too much. At other places, dormancy is needed to prevent heading in warm periods before danger of freezing is over. Smut resistance is a very important factor in many places. As a result of lack of resistance to Hessian fly and chinch bugs, there is no winter barley in sections that appear favorable otherwise.

---

## *The Nature of Some Major Breeding Problems*

**A**LTHOUGH the agronomic problems have been pointed out in this brief survey of breeding problems, a few merit more detailed treatment.

### LODGING

Lodging may be caused by a number of factors. Stiffness of straw is the first objective of every breeder who endeavors to produce a barley that does not lodge. However, this does not necessarily mean stiffness. Many times slender tough culms or stems do not lodge any more than large, erect, stiff ones. The best parent is the one that lodges least regardless of the reason. A barley that lodges early is worse than one that lodges late. When there is early lodging, the development of the kernels is affected and the grain ripens unevenly. In some dry areas, secondary roots are not formed and the plant is not braced. Such plants lodge from the crown merely by toppling over. Other varieties are weakened by their susceptibility to diseases. Regardless of the causes, strains differ greatly and most barley breeders are choosing parents and making selections resistant to lodging.

### WINTER HARDINESS

Winter barley is not so hardy as winter wheat or rye. It is more hardy than winter oats. The yields of winter barley are so large when it survives that there is demand for more hardy varieties along the northern edge of the winter barley region. There are inherent limitations in the plant itself that may prevent the development of a hardiness equal to that of wheat. In the Southeastern States, Tennessee Winter and Wisconsin Winter are the most hardy stocks. In western Oklahoma it is believed that other types probably arising from these are more resistant to the winter conditions of that region. In the Pacific Northwest the winter club types seem to possess the greatest hardiness. The problem of the breeder, then, has at least three divisions, on a geographical basis. At present he has nothing to start with but standard varieties.

## YIELD

Yield is the sum of many factors. In one place it may depend on earliness; in another on resistance to disease or to lodging. At all places it is tied up with the intangible something we call vigor. No one knows why Trebi should produce high yields in areas not well suited to its growth and where it is subject to leaf infection and is too late for the best results. It is not clear why the Coast barleys adapted to the West do so poorly when grown in the upper Mississippi Valley. We do have a means of measuring the net results of adaptation, vigor, and disease resistance. Comparative yields can be determined by growing varieties in competition and weighing the grain. Every breeder is doing this and in table 1 (p. 338), showing breeding activities at the various stations, yield is not mentioned, for no breeder could release a variety which does not yield well. Much progress has been made in producing higher yielding sorts and the "recommended varieties" listed in table 4 (p. 345), are all satisfactory in this respect.

## FEED

Most of our barley is destined to be used as feed. A surprisingly large proportion never leaves the farm on which it is grown. When a farmer grows feed for his own use, he is interested in but one thing—securing the greatest possible amount of feed from an acre of land. Yield is of the highest importance. It makes little difference to most farmers whether or not the hull frays. It is only when barley is rolled that a good hull is needed in feed barley. Diastase is unimportant. Kernel size is immaterial except as it may affect the amount of hull where hogs are to be fed. The grower may not even know whether the market cares for his variety or not. Smooth awns are often desirable. It makes the handling of the crop easier and the straw more useful for feed and bedding. In some cases barley is grown for forage. Tillering or branching and large amounts of roughage are the ends sought. Here hooded or smooth-awned types are desired, although much of the rough-awned barley of California is cut for hay.

It is easier to produce a feed than a malting barley. Fewer factors have to be considered and high-yielding sorts have been produced at many of our experiment stations.

## QUALITY

Quality, like yield, is affected by many factors, ranging from weather damage to chemical composition. Some of the factors fall in the breeders' province. Mellowness, the most intangible feature of quality, is largely dependent on the fitness of the variety to the region in which it is grown. When starch is formed in the kernel, there are many intermediate products. These halfway materials constitute a large percentage of the solids of the kernel in the early stages of growth. As the kernel develops these products constitute less and less of the total weight and in a fully mature and well-ripened kernel, they are negligible. Any barley kernel in which growth is interrupted will be "steely", that is, hard, with small-sized starch particles and intermediate products that dry down to a flinty mass. Such inter-

ruptions may come from disease, from drought, or, in humid climates, from hot weather. A barley that is well adapted to the section will avoid the bad effects of such adverse conditions better than one not well adapted. The varieties of the Pacific coast when grown in the West develop large starchy endosperms and are low in protein. The midwestern varieties when grown on the Pacific coast are lower in protein than when produced farther east, but in good years mellow barley is common in the upper Mississippi Valley.

Diastatic power is a measure of the ability of the kernel to convert starch to malt sugar. Some barleys have enough diastase to convert readily much more starch than is contained in the kernel. Most brewers desire such barley. Good diastatic power is partially dependent on the size of the kernels and it is relatively greater in the smaller kernels. Large-kerneled barleys, such as Coast, Atlas, and the two-rowed sorts, have a large starch endosperm. The scutellum, the part of the embryo which secretes the diastase, is little larger than that found in the smaller kerneled barleys. Naturally, then, such small-kerneled varieties as Oderbrucker and Manchuria, particularly as grown in the upper Mississippi Valley, are relatively richer in diastase.

All brewers desire a firm hull that is well attached to the kernel. Loosely attached hulls skin and fray, and, hence, do not make attractive malt, with the desired firm hull. The smooth-awned sorts are prone to have loose hulls. There is no reason known why well-attached hulls cannot be obtained in smooth-awned barleys.

Protein content is partly varietal and partly regional. Much of the protein is in the embryo and in the thin layer just beneath the hull, called the aleurone layer. In small-kerneled barleys these constitute a greater percentage of the total seed than they do in large-kerneled barleys. Both embryo and aleurone survive the brewing process and are found in the brewers' grains. Barley grown on rich land contains more protein than barley grown on lands of moderate fertility. Thin barley has more protein than plump barley. Barley grown in the humid areas contains a higher percentage of protein than barley grown in the West.

The breeder's avenue to quality is to produce barleys well adapted to the region—barleys that will mature well and will not lodge. Malting barley should be resistant to diseases. For our malting trade, small-kerneled barleys are important and easily obtained. The western export trade demands a larger kernel and the breeders of that section have suitable parental material at hand. In the smooth-awned varieties, selection for a tighter hull will not only better satisfy the maltster but will likely reduce the infection from loose smut as well.

## COLOR

Barley may be white, black, red, purple, or blue. The latter three colors are due to anthocyanin pigments, and when these pigments occur in the barley hulls, they are red or purple, but when they occur in the aleurone layer, they are blue. The white and blue varieties are the only ones grown extensively in the United States.

Blue barley has a peculiar status at the moment. In the upper Mississippi Valley the color is often considered an index of steeliness. This opinion persists despite the fact that the blue O. A. C. 21 of



Canada is fully satisfactory to those Canadian brewers who wish a six-rowed barley. It persists despite the fact that the only American barley that is bought at a premium on the English market is the blue barley of the Pacific coast. Indeed, when Atlas was introduced many English buyers complained that it was not blue enough. The breeder, then, is confronted with local market prejudices. An infinitesimal amount of a harmless pigment in a layer of tissue that is not modified in brewing may add one more factor that he must consider in breeding malting barley. We have many varieties of both blue and white barleys, and if it must be done, we can meet the market requirements.

### DISEASE RESISTANCE

The survey of superior germ plasm in barley made for the 1936 Year-book included inquiries as to the relative importance of diseases in the different States. In general, the replies showed the major problems to be limited to the effects of a few organisms. Because artificial epidemics in all cases cannot be obtained with uniformity, resistance cannot be fully studied and the point of attack is not always clear. It is necessary for the breeder to have a method of testing his strains for resistance to specific organisms before he can transfer the desired characters to his better barleys. The technique of inducing artificial epidemics is not equally advanced in all cases, and the status is indicated in the following discussion of the various diseases.

Scab is a serious disease in the Mississippi Valley. It is particularly bad on cornlands and heavy, poorly drained soils. It becomes more and more serious as barley growing is pushed southward into the hotter parts of the Corn Belt. In northern and western sections of the valley it decreases much as does the cultivation of corn itself. Its presence is ruinous to malting quality. It also makes the grain unsuited for feeding to hogs or horses, but it can be used for cattle and poultry.

Breeding for scab resistance is partially solved. Covering areas with cloth helps to induce high infections so that resistance can be studied effectively. This method is used at at least two stations. While evaluation of quantitative infection in plants that vary in leafiness and earliness is necessarily difficult, the present hope of obtaining scab resistance lies in using this procedure.

Covered smut is of more importance than loose smut. The latter seldom reaches high percentages. Loose smut is likely to be worse on smooth-awned varieties. As the teeth from the awns are re-



FIGURE 2.—R. A. Moore, identified with the early testing of varieties and the breeding of Oderbrucker.

moved, the hairs on the stigma are eliminated. This impedes fertilization and more flowers stand open until outside pollen effects fertilization. Loose smut spores may enter during the time the flowers are open. Both covered and loose smut exist throughout the barley-growing regions, but their importance varies from place to place. Breeding for smut resistance in barley has hardly commenced. Uniform artificial infections are difficult to secure and while progress is being made, a more dependable method of testing would be very welcome.

Stripe, like the smuts, is found more or less throughout the barley area. It is unimportant in market grain as kernels from plants affected by stripe seldom appear in the threshed grain. Its field importance, from the standpoint of reducing yield, is difficult to estimate. The percentage of plants killed is usually low, and where this is the case the plants die so early that their neighbors by using the space must compensate for much of the loss of stand. Recently a method of securing high infections of stripe has been developed and breeders are now able to test their progenies effectively for resistance.

Scald is practically limited to the Pacific coast. As with all leaf infections, it is difficult to appraise the actual damage.

Mildew is most common on the North Pacific coast and in the southeastern barley region. Infections are easily secured in the greenhouse and strains of barley vary in their resistance.

Foot rot (*Helminthosporium sativum*) is a serious seedling disease in the upper Mississippi Valley. Over a period of years it is probably the most serious disease of barley in this region. It is found throughout the United States but is less frequently serious elsewhere.

The technique of artificial inoculation is satisfactory for breeding purposes, and such varieties as Glabron and Velvet were subjected to foot-rot infections during the stages when selections were being made.

Blight is a term used to designate blackened kernels. It is caused and intensified by many different organisms. It is particularly important in malting barley, where the situation is complicated by the difficulty of distinguishing the effect of scab from other organisms that discolor kernels. The farmer is likely to lose by marketing blighted barley. His particular sample may be free from scab and thus be perfectly satisfactory for feeding purposes, but the buyer, being unable to determine the exact nature of the blighting, must discount the price.

Since blight is a market term, it means nothing to the breeder. The causes must be attacked separately, and the minor infections will probably not enter the field of breeding activities in the near future.

## PRESENT ACTIVITIES OF BREEDERS

Many problems of barley breeding are recognized. Others will become apparent from time to time. Problems and breeding activities are perennial. The solution of the problems we now see will require much time. The full force of plant breeding cannot be focused on barley. In many States it is a secondary crop. Even in the barley States, the personnel and funds available for breeding work are limited. The breeders often have other crops to look after and they must divide

their efforts as seems most advisable. Even where barley breeding is a major project, the breeder has to choose among the many things to be done. The amount of work at any station varies from time to time.

The Desirable Characters, Acreage, and History of Superior Varieties of Barley (p. 330) has been prepared in an effort to show which phases of the barley-breeding problem as a whole are under consideration at the various stations at the present time. At many stations, it will happen that the number of lines now being considered is less than has been the case at some previous period. However, the summary does picture existing activities and it will doubtless be useful to breeders working on the same problem.

---

## *Methods Used in the Breeding and Testing of Improved Varieties*

**B**ARLEY is a self-fertilized or close-fertilized grass. Usually the flowers are pollinated before the spike emerges from the boot. In many sections field hybrids are rare. Even where cross-pollination takes place, the resultant variations become homozygous within a few generations through self-fertilization. Breeding methods are based on the presumption that a homozygous strain will produce the same kind of barley as long as it is grown. Where the fields are pure this assumption seems to be sound for practical purposes. Fields of Trebi in southern Idaho, where the chances of mechanical admixtures are remote, show no plants that vary in height or type from the rest of the field. New varieties are based on the selection of single plants that differ in some way from the varieties already at hand. These variants may be ones already existing in fields or in introduced populations, or they may be induced by hybridization.

### FIELD SELECTIONS

The earlier barleys grown in North America consisted of a large number of similar types. Some of our best barleys have come from plants found by careful inspection of fields of these varieties. For example, Atlas is a selection from the Coast barley of California. In this case a large number of selections were made and grown for comparison by the usual methods of nursery testing. Selections such as these are homozygous and need only to be increased to constitute new varieties.

The same procedure is commonly practiced with importations from foreign countries. Many of these are bulk lots from remote districts in Asia and Africa. They are mixed as were our early varieties. They are first grown under detention to be sure that no disease is introduced with them. If free from disease, plant selections of the various types are made and tested. Trebi, Horn, and Peatland are examples of varieties which have originated in this way.

## HYBRIDIZATION

Most of the recent activities in barley breeding involve hybridization. Varieties of barley are easily crossed by artificial methods. The method of handling the hybrid populations depends considerably on the end to be attained. If the breeder is concerned with the production of a good barley and has no variety at hand that is outstanding, he may start on a large scale. In such cases the choosing of parents is difficult. Often the most logical cross has some inherent factors that make it unsatisfactory. On the other hand, barleys not very highly regarded may produce the offspring he is looking for. To insure a satisfactory combination, many crosses are sometimes made. One barley-breeding project now well advanced involves more than 400 separate combinations.

Once the hybrids are made, the problem is to find the desirable progeny lines. Several methods are in use. Some breeders select promising plants in the  $F_2$  generation. These lines are reselected each year until superior homozygous strains are obtained. Other breeders prefer to grow the hybrids in bulk for a few generations before selections are made. The theory back of this procedure is that it allows natural selection to eliminate some of the weaker lines. It also affords time for the progeny lines to become homozygous. The need for reselection is consequently reduced and the total amount of labor is much less. A larger number of crosses can be carried through this stage on no greater funds. A third method is to bulk many hybrids together in a field plot and reseed each year from machine-run grain harvested from the plot. This is the least expensive of the three methods. Of course, the record of the parentage of any varieties produced in this way is lost, if that is important. The relative value of the three methods is unknown. The fact that all three are in use is evidence that breeders do not agree. One extensive experiment is under way where 7,000 selections developed under the last two methods are to be compared. This should give some information as to their relative value.

At times a breeder is confronted with a more definite problem. He may have a variety that is satisfactory in all but one or two characters. In this case it is obvious that the deficiency may be overcome by crossing the variety with another which has the characters he wishes to add. If a single character is to be added, it can often be approached by backcrossing. For instance, if a white color was to be transferred to O. A. C. 21, this variety might be crossed on Oderbrucker. By repeated backcrossing to O. A. C. 21, all Oderbrucker characters except whiteness and those factors linked with it would be submerged. To retain the whiteness it would be necessary to carry an occasional generation to the  $F_2$  to be certain which lines still carried the white factor.

Real progress has been made in the testing of material. Yield tests are made in short rows repeated a sufficient number of times to give a reliable index of performance. Check rows aid in evaluating the effect of soil variations. Artificial epidemics of diseases are used at many places. These may be used before the selections are made and continued while they are being tested. In most States the selections are tested at least for yield at a number of places to smooth out environmental effects and to determine their usefulness in other

localities. In the Federal work they are often sent to many points. Selections that are only mediocre at the place where they are made often are valuable in some other locality. Strains that are superior in the nursery—a barley nursery is illustrated in figure 1—are usually grown in plots under field conditions for further proof of their value. Occasionally one is found which seems superior to those under cultivation. It is then increased and distributed to farmers.

---

## *The Germ Plasm Available to Breeders for Improvement Programs*

THE barley breeding of the future must depend upon the germ plasm available to breeders. There are three distinct reservoirs of germ plasm. We have the varieties under cultivation in the United States, and these are of proven value or they would not be grown. We have the collections of unproven viable material that are being carried by the United States Department of Agriculture and State experiment stations. Lastly, in remote localities of Asia and Africa, there remains an endless number of barleys as yet unknown to American growers.

### COMMERCIAL VARIETIES OF BARLEY IN NORTH AMERICA

No detailed survey of the acreage of the various varieties has been made. The survey of superior germ plasm included a request that the State agronomists estimate what percentage of the barley acreage in their respective States was planted to various varieties. These estimates are naturally not wholly dependable, but they do afford a general view of the varietal situation that would not otherwise be possible. These estimates have been translated into acreages on the basis of the July forecast. While July figures vary from the final ones obtained after the harvest, they are satisfactory in showing the general trend. Indeed, they are free from one disturbing factor—the abandonment of acreage that usually comes later. This is generally local and therefore affects some varieties more than others in any given year.

The results of the acreage estimates are reported in table 3 (p. 341). The varieties recommended by the State officials are also included.

It is apparent that most of the acreage in the United States is now being sown to varieties recently developed by plant breeders. It is obvious that such varieties are well adapted and are superior to the ones they are replacing. The plant breeder has every reason to feel gratified, and undoubtedly the time is not far distant when the entire acreage will be planted to pure-line varieties. There is, however, one rather disconcerting problem raised by the plant breeder's success. In a way we lose even when we gain. Our old varieties such as Manchuria, Coast, and Tennessee Winter contained a large number of forms. The possibilities of discovering additional strains of

unusual merit in these varieties are far from exhausted. But the acreage planted to them is shrinking rapidly. It will be difficult to maintain this particular reservoir of germ plasm in its entirety against the day when we may want it.

## COLLECTIONS OF BREEDING MATERIAL

The United States Department of Agriculture maintains a collection of more than 3,000 varieties of barley. These are kept viable by growing them every few years. In a way, the maintenance of such a collection is a natural Federal function. As long as the collection is available to all State workers who desire it, the maintenance of a single large collection avoids an expensive and profitless duplication. Of course, workers in many States are maintaining extensive stocks of material in which they are interested. In Colorado and California,

for instance, there are collections of interest to breeders. In Minnesota and Wisconsin there are strains thoroughly tested for their reactions to diseases. Collections in a number of other States contain valuable material. Somewhere, however, there should be preserved without loss the hundreds of barleys that have come to us through the kindness of travelers and the search of exploration parties. It may be that we will turn eventually to these little-known sorts for qualities not now recognized.

At present our most complete information concerns the commercial varieties. The commercial varieties of North America are quite well known. Their desirable characters have been discussed in State and Federal

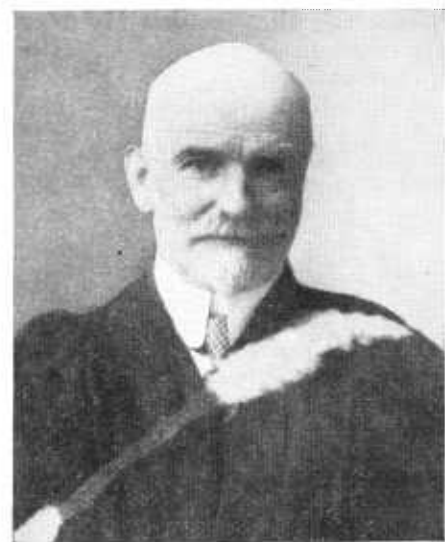


FIGURE 3.—C. A. Zavitz, Canadian plant breeder, producer of O. A. C. 21.

publications. They are available at least from commercial sources to any breeder in any amount. They are, of course, maintained in small amounts in State and Federal collections. These collections, however, include much more than the commercial varieties and are the most valuable property of the American plant breeder.

The breeder is helpless without living material of diverse character. A single strain of no commercial value may furnish a very important character. For instance, the variety, Lion, has provided the smooth-awned feature of every smooth-awned variety grown in North America today. It must be realized that full information is never available on any variety. This means that a much larger collection must be maintained than would at first seem necessary. When a new problem arises, the large number of varieties are available and a thorough search can be instituted for a quality not previously considered. More often than not a variety may prove useful in a way

not easily explained. One of the Egyptian varieties from the basins near Minia has excelled as a parent in many hybrid combinations. Yet this variety has, to date, not shown sufficient promise to be tested in field plots at any point. With a few exceptions we do not know what values may be tied up in the hundreds of barleys that lie in our collections. However, some day if a new disease should become important or a new market quality be demanded, we can turn to them as a possible starting point for a breeding program.

In addition to the variety, Lion, mentioned earlier, there are many sorts of potential value. The Ethiopian material contains varieties resistant to covered smut and to summer cold. Nakano Wase from Japan is an ideal parent for smut resistance, and breeders await only the perfection of methods of infection to make full use of it. In Pannier, an early barley from near Kashgar, Eastern Turkestan, the period in which floral organs are sensitive to frost is reduced to a point such that only scattering flowers are killed by subfreezing temperatures. Bon Farik produces large kernels and plants with few tillers; Tennessee Winter No. 52 tillers very heavily. Trebi is possessed of unusual vigor. The kernels of Smyrna enclosed in the boot continue to grow under conditions so dry that many varieties die completely. Many north-African sorts shatter but little. Peatland is resistant to lodging.

## OLD-WORLD RESERVOIRS IMPERILED

In the great laboratory of Asia, Europe, and Africa, unguided barley breeding has been going on for thousands of years. Types without number have arisen over an enormous area. The better ones have survived. Many of the surviving types are old. Spikes from Egyptian ruins can often be matched with those still growing in the basins along the Nile. The Egypt of the Pyramids, however, is probably recent in the history of barley. There would be little point in building an irrigation system before there were crops to grow. In the hinterlands of Asia there were probably barley fields when man was young.

The progenies of these fields with all their surviving variations constitute the world's priceless reservoir of germ plasm. It has waited through long centuries. Unfortunately, from the breeder's standpoint, it is now being imperiled. Historically, the tribes of Asia have not been overfriendly. Trade and commerce of a sort have always existed. They have existed, however, on a scale so small that agriculture has been little affected. Modern communication is a real threat. A hundred years ago, when the grain crop of north Africa failed, the natives starved. Today, in years of shortage, the French supply their dependent populations with seed from California. Arab farmers in Mariout sometimes sell short to European buyers and import seed grains from Palestine. In a similar way changes are slowly taking place in more remote places. When new barleys replace those grown by the farmers of Ethiopia or Tibet, the world will have lost something irreplaceable. When that day comes our collections, constituting as they do but a small fraction of the world's barleys, will assume an importance now hard to visualize.

## *A Survey of the Achievements Made in Barley Breeding*

**S**TRANGELY enough, the first real contribution in American barley breeding was accomplished by hybridization rather than by selection, as in the case of most plants. F. H. Horsford, of Charlotte, Vt., produced a covered hooded barley more than 50 years ago. Mr. Horsford, however, was ahead of his time, and the evolution of barley improvement in the United States flowed around his accomplishment almost as if it had not existed.

**T**HE contributions of the pioneers in breeding are not easily evaluated. They did more than breed plants. They paved the way for the generation that followed. They awakened the interest that led other men into the same fields. They effected contacts with the farming population. And with it all, they were successful breeders. They did not have adequate replications. They could not know the inheritance of many of the qualities for which they were working. They did not have available information on the role of certain diseases. Yet they did produce good barleys. This is a testimonial to the art of breeding, for it is an art as well as a science. The eye and the judgment of the breeder can never be wholly dispensed with. Judgment can be aided by perfection of technique, but many times in the handling of every extensive program the breeder must choose.

To get the story in full one must go back to the beginning. When North America was discovered there were no barleys here. Immigrants, however, always bring their seeds with them. The Spaniards were particularly fortunate in that Mexico is much like Spain in many ways and their grains were well adapted to the regions settled. Their barley arrived in New Mexico, Arizona, and California at an early date, and it was so well suited that the common Coast variety of California is still widely grown, though its origin with us dates back to the arrival of the Spaniard from Mexico. Earlier still, it traces to Spain, north Africa, and probably in some dim century to central Asia.



The barley growers along the Atlantic seaboard were not so fortunate. The English and Dutch settlers brought their grains, but the Atlantic States were not particularly good barley States, and the varieties from England and the Netherlands were not too well adapted. When western New York was reached, barley growing was advanced. Here was the first region well adapted to the growing of this crop. The six-rowed barley from Scotland was well suited to the climate, the soil, and the needs. The story was repeated in the upper Mississippi Valley, first with Scotch, then with Manchuria and Oderbrucker. When the Russians came to western Kansas they brought the Stavropol. Again, as with the Coast barley of the Spaniards, it was one naturally adapted to the new country, for the plains of western Kansas had many features in common with those of south Russia. In some

**I**N the great laboratory of Asia, Europe, and Africa, unguided barley breeding has been going on for thousands of years. Types without number have arisen over an enormous area. The better ones have survived. Many of the surviving types are old. Spikes from Egyptian ruins can often be matched with ones still growing in the basins along the Nile. The Egypt of the Pyramids, however, is probably recent in the history of barley. In the hinterlands of Asia there were probably barley fields when man was young. The progenies of these fields with all their surviving variations constitute the world's priceless reservoir of germ plasm. It has waited through long centuries. Unfortunately, from the breeder's standpoint, it is now being imperiled. When new barleys replace those grown by the farmers of Ethiopia or Tibet, the world will have lost something irreplaceable.

way not now clear a winter barley, probably from Switzerland or the Balkans, was introduced into the mountain region of the Southeastern States where it has long been grown as Tennessee Winter and Union Winter.

When barley breeding got its second wind, then, we had these four or five varieties dominating the acreage in North America. Each consisted of a large number of strains. The component strains of each variety were similar in general character and in climatic requirements. The present position of our barley-breeding program is based largely on these varieties as a starting point.

It is difficult to say when breeding started, or in fact exactly what breeding is. Was it breeding when the farmers of western New

York decided that of the varieties introduced the small-kerneled, early, six-rowed, was the one they wanted? Probably not. A little later, however, mixed populations of Manchuria and Oderbrucker fell into the hands of the agronomists in Wisconsin, Minnesota, and Ontario. These barleys proved to be good ones and efforts were made to find others. The record is not complete and progress was slow, for little had as yet been developed in plant breeding. Efficient methods of testing were not to be developed for more than a generation. Records were usually fragmentary and knowledge of Mendel's work was yet to come.

## THE WORK OF THE PIONEERS

Four men felt their way along the path of barley improvement, two in the United States and two in Canada. Willet M. Hays of Minnesota, R. A. Moore of Wisconsin (fig. 2), C. E. Saunders of Ottawa, and C. A. Zavitz of Guelph (fig. 3) were the pioneers on this side of the Atlantic. When these men turned barley breeding over to successors or assistants, the pioneer stage was over. Plot tests were reported from Wisconsin as early as 1871. Many barleys, mostly of European origin, were brought to Wisconsin to be tested in comparison with Manchuria and Oderbrucker.

After many years of experience, Moore decided that Oderbrucker was the barley best suited to his State. He set about to improve it first by elite, or mass, and later by pure-line selections. During much of the work he was aided by L. A. Stone. About 1908 Moore and Stone released Wisconsin Pedigree No. 5 and Wisconsin Pedigree No. 6. They were good varieties and are still being grown.

At Minnesota Hays had followed a somewhat different procedure. It is true there was the same preliminary period of varietal testing. Hays, however, was mostly interested in wheat. He commenced to make wheat crosses at an early date and recognized the need of more accurate methods of testing. In his breeding work he developed the centgener where 100 plants were equally spaced in a square. Barley breeding was a secondary project to Hays and, while barleys of hybrid origin were being tested in field plots as early as 1904, none was released for cultivation. Hays was responsible for a wide distribution of Minnesota 105, the original unselected Manchuria. He and H. K. Hayes are responsible for Minnesota 184, a Manchuria selection of some importance at present.

Zavitz at Guelph had much to do with the dissemination and improvement of the Manchuria-Oderbrucker barleys. He was a keen observer and his selections were good selections. His O. A. C. 21 is grown on a large acreage in Canada and is one of the important barleys in North America.

C. E. Saunders of Ottawa led the way in the production of hybrid barleys. As early as 1893 he was testing varieties of hybrid origin in field plots. His material was somewhat different from that of his three contemporaries. The Empire connections were evident in names of varieties in his test plots. Kangra Valley and Bagarmany Hills tell a story that names we are now applying may not recite. A large number of Saunders' hybrids were tested on the Dominion Experimental Farms and a few of them were grown at experiment stations in the United States. None is commercially grown this side of the border today.

The contributions of Hays, Saunders, Moore, and Zavitz are not easily evaluated. They did more than breed plants. They paved the way for the generation that followed. They awakened the interest that led other men into the same fields. They effected the contacts with the farming population that resulted in the support necessary for a broader program. And with it all, they were successful breeders. They did not have adequate replications. They could not know the inheritance of many of the qualities for which they were working. They did not have available information on the role of certain diseases, the consideration of which has played an important part in the creation of some of our new varieties. Yet they did produce good barleys. This is a testimonial to the art of breeding, for it is an art as well as a science. We can never wholly dispense with the eye and the judgment of the breeder. Judgment can be aided by perfection of technique, but, many times in the handling of every extensive program, the breeder must choose.

## THE NEW GENERATION OF BREEDERS

A new generation of barley breeders eventually inherited the opportunity to advance the program of improvement. No definite date marks the transition. The earlier breeders gradually withdrew to other fields and a slow infiltration of new men took place. Breeding activities were undertaken at places where improvement previously had not been attempted. By 1910 a considerable group of new men were becoming interested and by 1920 the present situation was well indicated. The testing methods had been much improved, both in agronomic and pathological problems.

Aside from the advantage of having better tools with which to work, the new breeders necessarily followed the general lines already laid down. As with the earlier workers, improvements were made by importations, by selections in mixed varieties, and by hybridization. The machinery for securing material from abroad was greatly expanded. Several thousand barleys have been brought into the country largely through the Federal Division of Plant Exploration and Introduction.

## INTRODUCED BARLEYS

While many of the introductions are invaluable as breeding stocks, few direct importations by either Federal or State agencies, aside from Manchuria and Oderbrucker, have become established in the United States. Club Mariout was brought from Egypt in 1904. In later years it was tested at a large number of stations west of the one-hundredth meridian. It was first released to the farmers of Oregon. Its largest acreage is now in California, where it is extensively grown as a crop for late seeding. It is a six-rowed, white, rough-awned variety with large kernels and a good hull. Ripened in fair weather, it assumes a golden color. Hannchen is a product of the famous plant-breeding station at Svalöf, Sweden. It has been tested widely throughout the United States. At present it is seeded on a considerable acreage in Oregon. It occurs as a mixture in fields of the upper Mississippi Valley. The fact that it seems to be increasing in this area would indicate that it could be grown there successfully

if there were any object in so doing. Hannchen is a two-rowed, white, rough-awned variety. California Mariout was introduced into California by the California Agricultural Experiment Station, having been received through E. Clemens Horst. It is a low-growing six-rowed, rough-awned barley, blue in color. It produces relatively high yields in the drier years. Once rather important, it is now grown on only a small acreage in California.

## SELECTIONS FROM IMPORTED VARIETIES

Selections from importations account for a considerable proportion of the present acreage. Besides the selections from Manchuria and Oderbrucker, there are four others of some importance: Atlas, Trebi, Horn, and Tennessee Winter. Atlas is a selection of the old Coast variety. It is now grown on a larger acreage in California than any other variety. It is similar to Coast, but rather lighter in color than most strains of the original Spanish barley. It is of fine quality and has a good hull. Trebi is a selection from a mixed barley imported from the hill country south of the Black Sea. It is widely grown in the Rocky Mountain region and in the Prairie States of the northern United States and adjacent Canada. It is seeded on a larger acreage than any other variety in North America today. It is a six-rowed variety, blue in color. The crop is mostly of feed grade except in the irrigated regions, where the quality is good. Horn, a two-rowed selection from a European barley, is seeded in Montana and adjacent areas. Peatland was isolated from a barley imported from Switzerland. It is useful in heavy soils and is resistant to spot blotch, root rot, and black stem rust, and moderately resistant to scab. There are several selections of Tennessee Winter under cultivation. While several southern experiment stations have worked with this variety, the earliest selections were released in Tennessee. Two recent selections are grown on a large acreage in Texas.

## SELECTIONS FROM HYBRIDS

Selections from hybrid populations are assuming more and more importance. Woven throughout the story of hybrid barleys is an obvious response to the farmers' dislike of rough awns. The awns of most barleys are stiff and heavily toothed. Such barleys are unpleasant to handle. About 1840 a variety which has a hood in place of the awn was introduced indirectly from Nepal. Its appeal to farmers was immediate and lasting. Although the yield is unsatisfactory, except in a few areas, seedsmen have always found it profitable to carry Nepal or Nepal hybrids. Most of the varieties produced by private breeders are hooded ones tracing to Nepal ancestry. As soon as Nepal was found unsatisfactory the plant breeders tried to improve it. As mentioned earlier, the first known hybrid selection in the United States was by F. H. Horsford of Charlotte, Vt., in 1879 or 1880. The Horsford variety and others originating in the same way have long been marketed under various names such as Beardless, Success, Success Beardless, etc. Among the early breeders to employ Nepal in hybrids was Robert Withecombe of Union, Oreg. He was in

an area where the Nepal types grew well under irrigation, and his work is undoubtedly the outstanding early work in the Pacific Northwest. His Union Beardless was distributed to farmers about 1910.

One of the more important projects for the production of a hooded barley started at the Tennessee Agricultural Experiment Station. C. A. Mooers (fig. 4), long connected with the chemistry department, took over the agronomic work in 1905. He immediately visualized the role that a hooded winter barley might play in the South. Farmers used to the growing of barley are willing to experience the discomfort of rough awns if thereby they can secure a higher yield. Farmers in sections where barley is little grown will seed hooded barley where they will refuse to grow a rough-awned barley. The hooded sort is much preferred for forage as well. Mooers' Tennessee No. 5 and Tennessee No. 6 have added much to the barley acreage of the South. They came from crosses of a hooded barley on Tennessee Winter. At present the acreage of winter barley in Missouri is being rapidly expanded by the use of Missouri Beardless, a hooded winter variety produced at the Missouri Agricultural Experiment Station.

Shattering and low yield are the weaknesses of the hooded sorts. As the senior author pointed out in 1920, the ash or mineral content of the rachis is increased when the awns are removed, thus causing the rachis to break more easily. This is particularly important in barleys of the eastern type. Those varieties commonly grown on the Pacific coast take up less silica from the soil. They

should and do produce hooded combinations which shatter less. In recent years, two hooded six-rowed hybrids involving nonshattering parents of the western type have made their appearance. These are Colless, produced at the Colorado Agricultural Experiment Station, and Meloy, originating in Oregon probably as a natural hybrid.

One of the most interesting hybrid barleys was Arlington Awnless, developed by H. B. Derr about 1909. From the progeny of a cross of Tennessee Winter on Black Arabian, Derr isolated an awnless variety. Both parents were long-awned. The form isolated had no awns on the lateral florets and only short points on the central one. The variety shattered badly and never became commercially important. It was soon replaced in tests and as a breeding stock by a similar barley from Japan which shattered less and was more hardy. The Japanese sort may have originated in the same way at some earlier date. In any case, the Derr barley will always interest breeders from the nature of its origin.



FIGURE 4.—C. A. Mooers, leader in the agronomic and breeding work with winter barleys in the United States.

## THE DEVELOPMENT OF SMOOTH-AWNED TYPES

Perhaps the most important barley-breeding project of recent years has been that of producing smooth-awned barleys. As was the case with Nepal, the smooth-awned sorts are more pleasant to harvest. They develop better and do not shatter as badly as the hooded forms. These barleys appeal to farmers and the demand has been insistent since the first varieties of this sort were introduced.

As far as this country is concerned, the program has been based almost entirely on a single variety, Lion, a smooth-awned black barley introduced from Russia in December 1911. It was not pure when introduced and a selection made in that year was named Lion. Lion was distributed widely over the United States. It was reselected at the Michigan Agricultural Experiment Station, and their variety, Michigan Black Barbless, may differ slightly from Lion. The first crosses were made in 1911 in the cooperative work between the Bureau of Plant Industry and the University of Minnesota. A variety similar to Lion which had been found as a stray in a miscellaneous collection from Russia grown at Minnesota was first used. The 1911 barley was weak-strawed and not at all vigorous, and in 1912 Lion was substituted and it was from its progeny that the early smooth-awned barleys came.

In the Mississippi Valley the first white smooth-awned hybrid barleys were not successful, being too susceptible to helminthosporium or foot rot. One of these, however, was crossed back on Luth and several other strains of Manchuria, and the progenies were subjected to artificial infection of helminthosporium. From these crosses came Velvet and Glabron. Velvet was the first smooth-awned barley to be grown in the upper Mississippi Valley. It was released in 1926 and the acreage expanded rapidly. Velvet is a high-yielding variety of good malting quality. It has better hulls than some of the other smooth-awned barleys. It is resistant to spot blotch and root rot. Glabron was released in 1929. The straw of Glabron is better than that of Velvet. It also has some resistance to smut and stripe as well as root rot and spot blotch. It is not pure as to color, containing both white and blue strains. Its hull is not so well attached as that of Velvet. Flynn was probably the earliest of all smooth-awned varieties to be cultivated by the farmers. This barley was grown in field plots at Moro, Oreg., in 1918 and was released shortly afterwards. Hero was tested in California as early as 1914, but was not released until after Flynn was in cultivation.

The smooth-awned variety, Vaughn, is an example of a hybrid barley that was almost a success. In California it has given tremendous yields. It has a straw that is among the best of our varieties. The hull, however, is thin and frays so badly that not only is it not wanted by the maltsters, but it is also unsatisfactory where barley is rolled. The variety grows well in Arizona, New Mexico, Texas, and western Kansas. In this section, where rolling is not a common practice and where most barley is not grown for malt, it may be useful. If, by further hybridization, the hull can be improved, it should be useful in California as well.

The Michigan Agricultural Experiment Station became interested in the smooth-awned barleys at an early date. Station workers reselected Lion and introduced it as Michigan Black Barbless. They also

isolated a smooth-awned type from Hanna and later produced Spartan. Spartan is a two-rowed variety with an exceptionally good straw and quite wide adaptation. The most recent arrivals in the field of smooth-awned barleys are Wisconsin Pedigree Nos. 37 and 38. The latter appears to be the better of the two varieties and seems destined to occupy an important place in the malting area of the northern Mississippi Valley. It has a good straw and yields well.

There are a number of recent hybrid barleys which are not smooth-awned. Svansota, Minsturdi, and Alpha were developed at the Minnesota Agricultural Experiment Station. Alpha came from a cross made in the early cooperative work and was sent to the plant-breeding department of Cornell University in 1913. That department determined its value and distributed it to farmers of New York State.

## THE WORK OF PRIVATE BREEDERS

The accomplishments of private breeders are not extensive. The nature of the barley crop is such that a breeder cannot retain exclusive control of the seed supplies a sufficient length of time to make it profitable. Horsford expressed this idea many years ago and even suggested a plant patent. Aside from Horsford's barley, private breeders have been responsible for a number of others. George Meloy, with the assistance of D. E. Stephens, established the variety, Meloy. A. J. Faust, of Dillon, Mont., selected the Faust variety from a field of Himalaya. Two breeders in South Carolina have made selections from the Tennessee Beardless. Each was developed from single plants. These are Douthits Beardless by J. B. Douthit, Pendleton, S. C., and Maretts Strains No. 1 and No. 2 by the Maret Farm & Seed Co., of Westminster, S. C.

It will be noted that these varieties all involve the hooded character. T. W. Wood & Sons of Richmond, Va., have promoted the use of awnless and hooded sorts. The Coker's Pedigreed Seed Co. of Hartsville, S. C., will probably be as successful with barley as they have been with other small grains. Most of the other seed firms in the United States have been concerned with the distribution phase of varieties. Many of them have given valuable cooperation in establishing new sorts, but should hardly be included in a breeding survey.

Barley breeding is, in a way, perpetual, and any survey is confronted with the difficulty of appraising unproven stocks. In many breeding nurseries throughout the country there are strains which will constitute the varieties of tomorrow. The present survey is so timed that, at some stations, established sorts are in commercial production, at others, varieties have recently been released and their possibilities are not yet fully determined. Still other varieties are soon to be offered to the growers, but at many places further testing must be done.

The Maryland Agricultural Experiment Station is expecting to release a smooth-awned winter barley in 1936. A similar variety is being produced at the Kentucky Agricultural Experiment Station, and a smooth-awned spring type has given evidence of value in Idaho.

The testing period is about completed on some strains in North Carolina. There are doubtless others in a similar stage of development that were not recorded in the survey.

## *The Survey of Superior Varieties of Barley*

IN THE papendix (pp. 330-338) is a series of "thumbnail" sketches of the varieties of barley at present considered superior. As far as they are known, the superior qualities of each are stated. Estimates of acreage are included to show the importance of the variety. An historical paragraph gives information as to the method of production, the workers concerned, and the year the variety was released.

No such statement can be complete or fully accurate. The acreage estimates are based on the best judgment of State and Federal officials. In most cases State officials estimated the percentage of each variety in their States. These were translated into acres by using the July 1935 forecast of the Division of Crop and Livestock Estimates, Bureau of Agricultural Economics, United States Department of Agriculture.

The history of some varieties is already lost. The recording of that of others is timely. Many details can be supplied now by personal familiarity with early field notebooks. The third generation of American barley workers will not have this—and that generation is already here, but generation no. 2 does not yet realize it. The breeders directly responsible for the varieties have been recorded as completely as is possible. Unfortunately, there is no way of recording the equally valuable work of those who tested the varieties and the efforts of executives who freed the breeders from executive details and gave them the facilities for work.

The achievements of many workers have been discussed, and more are included in the sketches of barley varieties in the appendix. But there are many more instances where no concrete results in breeding can be reported. This is particularly true in the case of the present workers, many of whom are at the beginning of their careers. Often they have not been employed for a sufficient time to obtain results. In other cases the proportion of their time allotted to barley is insufficient for any adequate program. Often the activities are limited to the determination of which varieties already in existence are best suited to given conditions. This, in a way, is of the very highest service to the State. The number of commercial varieties should be limited. It is of importance in the brewing trade that varieties reach the market unmixed with others. The greater the number of varieties the more difficult this becomes. For the benefit of agriculture as a whole, these men are doing a greater service than if they evolved varieties of their own, unless of course the latter be distinctly better. Such service, however, is not of a nature that is easily recorded in this survey, except by inference in the recommended varieties. It requires more work to test a variety than to produce one.

The past and present workers in the experiment stations of the United States are listed in table 2 (p. 339). A tabulation of this sort is difficult. There is no clear-cut distinction between "early" workers and "present" workers. A man who resigned to accept a new position in 1934 cannot be listed as a "present" worker at the station which he has left. In many cases older men in charge of departments have



turned the barley work over to an assistant. They are no longer "present" workers, but at any time they may again become interested in barley. The classification as it appears here is, then, merely a matter of convenience to those who may wish to get in touch with the active workers of 1935.

---

## *A Brief Summary of the Work of Foreign Breeders*

THE field of foreign activities is too broad to receive more than a brief mention in this survey. Even if we limit it to those phases of particular interest to American breeders, adequate treatment is impossible. Contacts are infrequent and the literature portrays the past rather than the present. If the information were fully available, barley breeders would doubtless be most interested in the varieties produced, the personnel, and the breeding material.

Many of the varieties produced in other countries are well known to American breeders. The more important ones have been brought in time after time and have been widely tested. As far as Canadian workers are concerned, they can hardly be considered as foreign. The barley acreage of the United States and Canada is divided by a political boundary. A variety adapted to the southern border of the Prairie Provinces of Canada is equally well suited to the northern portion of our Prairie States. Varieties are interchanged by farmers as well as by experiment stations. O. A. C. 21 is well known on our markets. Even strains that originated in noncontiguous Provinces are tested this side of the line and vice versa. Charlottetown 80, developed in Prince Edward Island, was widely tested in the United States.

Perhaps the varieties originating at the plant-breeding station at Svalof, Sweden, have had a more exhaustive trial in the United States than those of any overseas country. Svanhals, Hannchen, Primus, and Gold have been grown at practically every one of the experiment stations in the barley States. Hannchen appears in considerable quantities on our markets today.

Barley does not grow well in hot, humid climates. Under arid conditions its culture is successful even in the Tropics, but under humid conditions it grows well only in the cooler regions. The American acreage in the northern Mississippi Valley and the Eastern States is relatively far south for barley grown under humid conditions. For this reason varieties produced in England and much of Europe are not well adapted to the United States. There is a small acreage of Hanna, and at one time there was a limited acreage of Chevalier in the cool Salinas Valley of California, in the Gallatin Valley of Montana, and in parts of New England. At the present time, however, varieties from breeding stations in Europe have a limited interest to the American grower. Conditions in parts of the Union of Soviet Socialist Republics are similar to those in some localities in North America. Two Russian barleys, Odessa and Stavropol, are already grown extensively in the Plains States. The survey indicates that almost 1,000,000 acres are seeded to Odessa annually. The future

productions of Russian breeders are likely to be of great interest to American farmers.

For the more arid sections of the Plains, parts of the Great Basin, and the Pacific coast, we should look to Spain, north Africa, Chile, and Australia. Over a million acres are now seeded to varieties that trace indirectly to Spain and north Africa. The Australian varieties of barley have not as yet assumed as much importance with us as have the Australian wheats. One two-rowed variety, Pryor, is the earliest two-rowed sort in our collections. The Japanese productions are not well suited to American conditions. One of them, an awnless variety received only under the descriptive name of Nakano Wase, has a potential value as a breeding stock for smut resistance.

Mention of foreign personnel is attended with many difficulties. Their interest to American breeders is partially dependent on loca-

tion. Those in regions similar to the United States in climate and soil are more likely to produce varieties of value to us than those in other sections. Complete information is never available and only a few breeders can be discussed in any ease. Men like Tschermak, Regel, Nilsson-Ehle, and Hans Tedin are of importance not only from their actual work, but from the direction which they gave to barley improvement in later years. The English breeders, Engledow, Hunter, and Beaven, are household names in barley literature. Vavilov (fig. 5), in the Union of Soviet Socialist Republics, is a world figure in cereals. Several of his assistants are in the front rank today. Vestergaard is outstanding in Denmark. Blaringhem, in



FIGURE 5.—N. I. Vavilov, chief, Bureau of Plant Industry, Union of Soviet Socialist Republics, plant explorer and student of barley.

France, despite his many and varied interests, has found time to publish many papers on barley since 1904. Old establishments such as the one at Svalöf, Sweden, and the firm of Vilmorin et Cie., in Paris, have had a profound influence. Duecellier in Algeria, Miede in Morocco, and Boeuf in Tunisia are doing work of particular interest to us. The name of Von Proskowitz is linked with the breeding work of old Austria. Many private breeders in Germany have developed barleys well known in American experiment stations. Due to the fact that their varieties are not suited to American conditions, the Japanese breeders are not so well known in North America. Their genetic work, however, is recognized as being of high standard. A few of the foreign workers are listed in the appendix.

The breeding materials in the hands of barley breeders over the world may be of importance to us at any moment. The Russian collection is undoubtedly the most extensive in existence today. Vavilov

personally has searched almost every country of the world and has accumulated an enormous number of forms. He has sent many expeditions into the Caucasus and central Asia. Many types have been added from time to time by such explorations, as the Mongolian expedition of Pissereff. Our collections have been expanded by his generous donations. Ducellier and others have collected material from the oases of the Sahara. Some of these are very striking and may furnish us with entirely new characters to use in our breeding program.

---

## *The Need for Further Study of the Genetics of Barley*

**I**N MANY ways barley is an attractive plant to use in inheritance studies. All cultivated barleys, so far as is known, have seven chromosomes. The number of distinct characters is large. Seed may be naked or covered; lemmas awned, hooded, or awnless; colors range from white through various anthocyanin pigments to a melaninlike black. The anthocyanin pigments may be in the lemma and palet, in the seed covering, or in the aleurone layer. Even such fundamental differences exist as in the number of fertile spikelets of a node of the rachis. There are very many minor variations.

Unfortunately, some of the barley characters are not too readily classified. For instance, when Nepal is crossed on a barley of the Coast type, hoods and awns are secured in the usual ratio of 3 to 1. If, however, the breeder wishes a hooded segregate with the hoods fully sessile as in Nepal, the presence of other factors becomes apparent, for most of the hoods are not sessile.

The inheritance of smooth awns is equally complex. A gross classification of the progeny shows one-fourth of the awns to be smooth. Many of these are not so smooth as was the smooth-awned parent. A greater refinement suggests a two-factor relationship. In actual breeding practice, where barleys of the Coast type are used for the rough-awned parents, an assumption of still more factors may be needed.

The difficulties in barley breeding, however, are only such as the geneticist must meet everywhere, and much good work has been done.



FIGURE 6.—D. W. Robertson, leader in American barley genetics.

Fortunately, the achievements tabulate well. Orderly work such as that of Robertson (fig. 6) is so clear in the tabular summary contained in the appendix (p. 341) that no discussion by a second party could add anything of value. The work of Buckley and Hor, on the other hand, was not summarized for this survey by the authors. This is not quite fair to them as they may have been able to make a more complete statement. The published reports of these authors gave no definite information as to the parents used. In both cases the ratios are summarized in one column and the linkages stated in another. In the summaries of these two authors the alignment is without significance, that is, the cross-overs are not placed opposite the ratios secured from the same hybrids. The omission of information concerning the parents is unfortunate as some other worker may wish to make use of the same material. It should be stated in connection with Buckley's cross-over percentages that in cases like red pericarp and purple lemma the classification is difficult. The intensity of anthocyanin colors depends on many factors other than genetic ones.

The nature of future studies can only be surmised. We need some method of studying the more easily influenced variants, such as time of heading and winter dormancy. Progenies grown at different places or in successive plantings at the same place give widely varying results that are difficult to analyze. We likewise need to correlate some of the activities. Mutations induced by X-rays, such as have been secured by L. J. Stadler and others, will doubtless add much to our knowledge of barley genetics. A closer contact with plant material and projects of other workers may be part of a future program. A correlation of plans for work to be done should yield many times the dividend that can accrue from any analysis delayed until independent projects are completed.

## Appendix

### The Desirable Characters, Acreage, and History of Superior Varieties of Barley

*Ace* is a two-rowed, white, rough-awned, early variety resistant to drought. It produces good yields under semiarid conditions. At present it is grown on about 117,000 acres, all in South Dakota.

The variety was distributed in 1918 from Highmore, S. Dak., the South Dakota Agricultural Experiment Station and the United States Department of Agriculture cooperating. It was produced by J. D. Morrison, who selected this and other early types from the well-known variety, White Smyrna. It is earlier and shorter than the parent variety, but otherwise similar to it.

*Alpha* is one of the few two-rowed varieties commercially grown in North America. It is rough-awned, white in color, has a good straw, and produces high yields in the Northeastern States. In 1935 it was grown on approximately 161,000 acres, mostly in New York State. It has proved particularly suited for growing in fields of mixed grain. The mixed-grain acreage often is not reported as barley.

The original selection was made by H. V. Harlan from a cross of Manchuria  $\times$  Champion of Vermont. The selection was made at St. Paul, Minn., in the cooperative work of the Minnesota Agricultural Experiment Station and the United States Department of Agriculture. It was sent to Ithaca, N. Y., in 1913 and from there distributed to farmers through Cornell University, the United States Department of Agriculture cooperating.

*Atlas* is the most important barley grown in California. It is early, stiff-strawed, and produces large yields of grain of high malting quality. It is a rough-awned, six-rowed variety, less blue than Coast. It is now grown on 650,000 acres, almost wholly in California.

It was distributed from Davis, Calif., in 1924 in the cooperative work of the University of California and the United States Department of Agriculture. Atlas was one of several hundred selections made by H. V. Harlan and V. H. Florell from the Coast or common barley of California.

*Arlington Awnless* is apparently useful only as a breeding stock. Its one character of value lies in the fact that it produces neither awns nor hoods. There is no commercial acreage.

It was distributed in 1911 from Arlington, Va., by the United States Department of Agriculture. It was produced by H. B. Derr, who selected it from a cross of Tennessee Winter on Black Arabian. Both of these are bearded barleys.

*Beldi Giant* is a stiff-strawed, high-yielding, six-rowed variety with large blue kernels. The awns are quite rough and the hull is heavy but good. The present acreage is about 27,000 acres, all in the State of Washington. The origin is not clear. It was secured from the California Agricultural Experiment Station by the United States Department of Agriculture about 1913 under the name of Beldi. It differed so materially from the Beldi of the Department of Agriculture that H. V. Harlan made a selection of it, renamed it Beldi Giant, and sent it to a considerable number of western stations. It was later distributed to farmers by the Washington Agricultural Experiment Station. Beldi Giant is probably an introduction from north Africa. The word Beldi is most likely a corruption of the Arabic term for "village." In other words, Beldi probably means "common" barley and varies from place to place in north Africa.

*California 4000* is limited in its distribution to California, where the present acreage is about 12,000 acres. It is a six-rowed, rough-awned, blue barley that produces high yields of grain suitable for both feed and malting.

The variety is a product of the California Agricultural Experiment Station. It was released to farmers in 1916. It is a selection made by B. A. Madson from Coast, the common barley of California.

*California Mariout* is a six-rowed, rough-awned, low-growing, blue-kernelled variety. It is very early and produces good yields with relatively little moisture. The grain is of feed quality and the variety is adapted only to California and the Southwest. Although formerly grown on a considerable acreage, there is little in cultivation at this date.

G. W. Shaw and G. W. Hendry distributed *California Mariout* in 1912. It was an introduction from Egypt which they secured through E. Clemens Horst, of San Francisco. In Egypt the variety is grown by Arab farmers along the Mediterranean, where it matures without irrigation with a rainfall of about 8 inches.

*California Tennessee Winter* is adapted to the heavier lands of California, where it produces high yields of grain suited for both feed and malting. It is not a true Winter barley and is not similar to the Tennessee Winter of the South-eastern States. It is of the Coast type with harsh awns and blue kernels. The California Tennessee Winter has an acreage of 118,000 acres, all of which is in California.

It was selected by B. A. Madson and distributed by him in 1916. Its origin is not certain, but it is thought by the California authorities to be a selection of one of the Coast types.

*Club Mariout* is particularly valuable for late seeding in California, where the shortened period from planting time until maturity is well utilized by this variety. It also yields well under conditions of light rainfall, as in eastern Oregon and eastern Colorado. It is a six-rowed, rough-awned variety, with a dense head of white kernels. In 1935 the acreage of Club Mariout was estimated to be 233,000 acres, most of which is in California.

The variety was introduced by the United States Department of Agriculture from the irrigated sections of lower Egypt in 1903. The first commercial acreage was in Oregon. In 1919 G. W. Hendry brought some of the barley into California in carload lots. It has been a staple barley there ever since.

*Coast* has long been popular with the English brewers. It has been the major feed grain of the Western States since their settlement, and in certain sections such as the interior valley of California the quality is high. It is a mixture consisting of a large number of strains of six-rowed, rough-awned barley. These strains vary in the amount of blue pigment they contain. At present it is grown on about 328,000 acres, the largest areas being in California and Colorado.

This variety was introduced into California about 1770 by the early Spanish missionaries from Mexico. Earlier it doubtless came to Mexico from Spain and to Spain from north Africa.

*Colless* is a hooded, stiff-strawed variety which has given high yields in Colorado. It shatters less than many of the hooded sorts. It is seeded on about 18,000 acres, all in Colorado.

It was distributed in 1911 by the Colorado Agricultural Experiment Station. It was developed by D. W. Freer and the staff of the Colorado station, from a hybrid of Coast  $\times$  Beardless.

*Comfort* and *Short Comfort* are smooth-awned, six-rowed varieties which produce good yields. On the whole they are not so smooth as Glabron and Wisconsin Pedigree 38. *Comfort* was produced at the Minnesota Agricultural Experiment Station in the cooperative work of the United States Department of Agriculture in the smooth-awned project of Hayes, Harlan, Stakman, etc. It came from a cross of a smooth-awned segregate, *Manchuria*  $\times$  *Lion* crossed on Luth. Luth is a plant selection of *Manchuria* made by Harlan in southeastern Minnesota. Two separate lots were sent to the Nebraska Agricultural Experiment Station. One of these was found by Kisselbach to be shorter than the other and he distributed it to farmers as *Short Comfort*. At present *Short Comfort* is grown on about 121,000 acres in Nebraska, while *Comfort* is grown on 53,000 acres in Nebraska and Pennsylvania.

*Esaw* is a productive winter variety resistant to covered smut. It is an early, six-rowed, rough-awned, white-kerneled variety. The commercial acreage is unimportant.

*Esaw* was distributed from the Arlington Experiment Farm in 1930 by the United States Department of Agriculture. It was selected from a Nakano Wase hybrid by J. W. Taylor.

*Ezond* is the result of an effort to develop a smooth-awned Trebi barley. It is believed that this variety possesses the vigor and yielding capacity of the Trebi parent, but this is not yet fully demonstrated. There is no commercial acreage.

*Ezond* came from a cross of Trebi on Loudon made by G. A. Wicbe. Loudon is a smooth-awned segregate of Bay Brewing  $\times$  Lion. The  $F_1$  and plants of later generations were backcrossed on Trebi. A segregate was increased and tested several years ago at Aberdeen, Idaho, where all the work has been done in cooperation between the United States Department of Agriculture and the Idaho Agricultural Experiment Station. The first segregate produced high yields and was tested at a limited number of experiment stations. The smooth-awned character was not fixed. Some plants were partially smooth, some slightly rough, and some quite smooth. Harland Stevens at Aberdeen, Idaho, made a large number of selections from the variety. A few of these proved to be entirely smooth and have remained so in larger tests now being conducted. The best of these again carries the name *Ezond*.

*Faust* is a hooded, naked, six-rowed barley of the Nepal type. It has produced high yields for this type of barley in western Montana. The variety is grown on 6,000 acres, all in Montana.

A. J. Faust, of Dillon, Mont., found a hooded plant in a field of Himalaya. It obviously was a field hybrid, probably of Nepal  $\times$  Himalaya. He increased the seed of this plant and the variety known as *Faust* was later grown by him and tested by the Montana Agricultural Experiment Station.

*Featherston* is a six-rowed, rough-awned barley of the Manchuria type which produces high yields in the Northeastern States. Although more widely grown at one time, it is now limited to about 3,500 acres, all in New York State.

*Featherston* came from a selection made by H. V. Harlan in a field of Manchuria barley near Red Wing, Minn. It was first grown at St. Paul, Minn., in cooperative work with the United States Department of Agriculture and the Minnesota station. It was sent to Ithaca, N. Y., in 1913, where it was tested in the cooperative work of the Department and Cornell University and distributed to farmers from that place.

*Flynn* is a six-rowed, smooth-awned, white-kerneled barley with a good straw and of moderate height. It has produced good yields in eastern Oregon and in western Kansas. The commercial acreage is insignificant.

*Flynn* came from a cross of Club Mariout  $\times$  Lion made at St. Paul, Minn., by H. V. Harlan in the cooperative work between the Minnesota station and the United States Department of Agriculture. A number of selections from this cross, including *Flynn*, were sent to several western stations. At Moro, Oreg., *Flynn* was chosen by D. E. Stephens in the cooperative work between the Department and the Oregon station as the best of these selections and was distributed to farmers.

*Glabron* is one of the more important smooth-awned barleys. It has an unusually good straw, yields well, is resistant to smut, spot blotch, and root rot, and moderately resistant to stripe. It is adapted to the upper Mississippi Valley, where it is now grown on 813,000 acres.

*Glabron* was distributed from the Minnesota Agricultural Experiment Station in 1929. It was produced in the cooperative work between the Minnesota station and the United States Department of Agriculture. Its history is slightly involved. In the early development of the smooth-awned barleys, *Lion* was crossed on *Manchuria*. A smooth-awned segregate from this cross was used in 1917 to cross again on *Manchuria*. From the second cross, *Glabron* was isolated. In the production of the variety H. K. Hayes, H. V. Harlan, F. Griffée, E. C. Stakman, and J. J. Christensen all had a part. The plant-breeding and plant-pathology sections of the university joined forces to isolate selections valuable for their agronomic characters and resistant to some of the serious diseases. *Glabron* is a good example of profitable cooperation between those engaged in agronomic and those engaged in pathological research.

*Hannechen* has given better yields and has exhibited a much wider range than other barleys imported from Svalof, Sweden, and similarly has the widest range of any two-rowed barley grown in North America today. It has a good straw and produces grain of high quality. It is now grown on more than 60,000 acres, more than three-fourths of which are in Oregon.

*Hannechen* came from a plant selection made from *Hanna* at the plant-breeding station at Svalof. It was introduced into the United States by the Department of Agriculture in 1904. It was distributed to a large number of stations and was in the hands of farmers about 1908. The Oregon stations have found it well suited to western Oregon and the irrigated districts of the Klamath section. It is surviving as a mixture in other varieties in the northern Mississippi Valley, where it seems to be increasing in the fields.

*Hero* is a six-rowed variety with smooth awns and a good straw. It yields well in a limited section of California and under irrigation in southern Arizona. It is grown on about 60,000 acres, practically all of which are in California.

The history of *Hero* is interesting because of the number of agencies involved in its development. A cross between *Lion* × *Club Mariout* was made in the Federal greenhouse, Rosslyn, Va., in 1912 by H. V. Harlan. Two generations of progeny were grown at St. Paul, Minn., in cooperation between the Federal Department of Agriculture and the Minnesota Agricultural Experiment Station. Several plant selections were made and sent to experiment stations in the West, including Chico, Calif., in 1915. The variety was grown at Chico until 1921. In 1922 the variety was named *Hero*, and in the same year the work was transferred to Davis. Later, W. W. Mackie, of the California Agricultural Experiment Station, made a plant selection which he distributed in 1924 to California growers as *Hero*. It is obvious that this variety would not be in the hands of farmers today if any of the steps in the Federal and State cooperation had been lacking. It is equally obvious that scientific credit cannot be apportioned or decided. The work was done, however, through facilities afforded by the University of California and was made possible by the cooperation of B. A. Madson. Madson's part in the production of the more important variety, *Atlas*, at the same station is even more valuable. Through his assumption of the administrative details, the workers who developed that variety were able to devote their time to the details of the breeding program.

*Himalaya* is a blue, naked, rough-awned, six-rowed barley. It is the highest yielding naked sort grown in North America. It is grown scatteringly throughout the West, but most of its 5,000 acres are in Montana.

It is a common barley of central Asia and extends to the higher altitudes in northern India. It has been imported many times, tested at most of the experiment stations in the United States, and released at various places.

*Horn* is a rough-awned, white, two-rowed barley which has produced high yields on the dry lands of Wyoming and Montana. It is now grown on 110,000 acres, and its distribution is limited mostly to Montana, Wyoming, and South Dakota. The acreage was considerably in excess of this figure, before the recent drought period, in the area of its distribution.

The parent material was secured at the Paris Exposition in 1900 from the Austrian exhibit. In 1909 H. V. Harlan made the selection of the present variety at St. Paul, Minn., in the cooperative work between the University of Minnesota and the United States Department of Agriculture. The variety was tested at a number of western stations, but was probably first released in Wyoming. In

recent years the Montana Agricultural Experiment Station has done much to extend the acreage of Horn in Montana.

*Horsford* is a hooded, covered, six-rowed barley grown here and there throughout the Eastern and Midwestern States. The variety shatters badly and does not produce high yields. It is estimated that 34,000 acres are planted annually to this variety.

The term *Horsford* includes a number of similar barleys of separate origin. The first of these was produced by Mr. Horsford, of Charlotte, Vt., in 1879 or 1880. It was a cross of Nepal on one of the common six-rowed, bearded barleys of the Eastern States. Similar crosses were made later, and field hybrids of Nepal are not uncommon. Seedsmen have carried this sort of barley under various names, *Success* and *Success Beardless* being two of the more common.

*Kentucky 1* and *Kentucky 2* are both winter-hardy and adapted to Kentucky conditions. *Kentucky 1* produces the higher yield and is grown on between 2,000 and 3,000 acres, most of which are in Kentucky and Missouri.

These varieties were selected from the old winter barley long grown in Kentucky and commonly known as Tennessee and Union Winter. The plant selections were made by E. J. Kinney, of the Kentucky Agricultural Experiment Station, who released them to farmers in 1930.

*Kentucky 11* is a smooth-awned, six-rowed, cold-resistant winter barley. It has no farm distribution as yet.

This variety was produced by E. J. Kinney, of the Kentucky station. It came from a cross of a smooth-awned spring variety on the local winter.

*Lion* has been widely used as a parent in hybrids. It is smooth-awned, black, six-rowed, and of fair yielding capacity. Its main contribution is an unusually smooth awn that is highly stable for smoothness. There is no commercial acreage.

In 1911 the United States Department of Agriculture received a black, six-rowed barley from Taganrog, Russia. A small plot was grown at St. Paul, Minn., in 1912 in the cooperative experiments of the United States Department of Agriculture and the Minnesota station. Both smooth and rough types were present. H. V. Harlan made a number of selections, one of which (*Lion*) was used in crosses and distributed to many experiment stations.

*Michigan Black Barbless*: In 1913 *Lion* was sent to the Michigan Agricultural Experiment Station. F. A. Spragg reselected the variety and in 1918 released his selection as *Michigan Black Barbless*. It is grown on about 2,000 acres in Michigan.

Since *Lion* was already a pure line, any difference at Michigan must have been due to accidental impurity of the seed. It is possible that the *Lion* sent included other strains of the original Taganrog barley.

*Manchuria* is a vigorous, six-rowed, rough-awned, early barley tolerant to moderately high temperatures and humidity. The estimated acreage of this variety in 1935 was 1,229,000.

The first importation of *Manchuria* seems to have been made about 1861, when Herman Grunow, of Mifflin, Wis., secured it from Germany. It was later grown as Minnesota 6 and under such names as *Manshury* and *Mansury*. In 1881 the Ontario Agricultural College at Guelph, Canada, imported a barley which they distributed as *Mandscheuri*. It was similar to the earlier introduction. Both barleys contained a large number of strains, some with blue aleurone layer, some with white. Many valuable selections have been made from these stocks.

*Minnesota 184* is a selection of the original *Manchuria*. It is superior in yield and malting quality, and is resistant to spot blotch and root rot, and moderately so to loose smut. It was grown on 668,000 acres in Minnesota in 1935.

It was selected from Minnesota 105, the Ontario *Mandscheuri*. The selection was made and tested by W. M. Hays, C. P. Bull, and H. K. Hayes. It was distributed in 1918.

*Meloy* is a hooded, six-rowed, blue variety which shatters less than do most hooded hybrids. It is grown on about 8,000 acres in eastern Oregon.

The variety, a field hybrid, was found by George Meloy near Moro, Oreg. One parent was probably a barley of the Coast type. D. E. Stephens secured the variety from Meloy and, after testing it in the cooperative tests of the Oregon Agricultural Experiment Station and the United States Department of Agriculture at Moro, distributed it to farmers in Oregon.

*Michigan Winter* is one of the more winter-hardy barleys. It is six-rowed and rough-awned. It is grown on about 2,000 acres in Michigan.



The variety came from a plant selection Derr Winter made by F. A. Spragg. The Derr Winter was probably of the Tennessee Winter type. The Michigan station distributed this variety in 1914.

*Missouri Early Beardless* is an early, hooded, six-rowed winter barley particularly well adapted to southern Missouri. It was grown on about 1,000 acres in 1935. In the fall of 1935 the seeding was increased to about 12,000 acres.

The variety was produced by C. A. Helm at the Missouri Agricultural Experiment Station by mass selection in a commercial variety without name. It was first distributed by the Missouri station in 1933.

*Nakano Wase* is valuable as a breeding stock. It is an early, awnless, six-rowed winter variety with good straw and is resistant to smut. There is no commercial acreage.

The present selection of Nakano Wase was made by J. W. Taylor and released in 1924 from the Arlington (Va.) Experiment Farm. The parent variety was introduced by the United States Department of Agriculture from Japan in 1911 under the purely descriptive name of Nakano Wase (meaning medium early).

*Nobarb* is a smooth-awned, six-rowed winter barley. It is one of the varieties to be released in 1936. It was produced by W. B. Kemp, of the Maryland Agricultural Experiment Station, from a hybrid Tennessee Winter  $\times$  Smooth-Awn.

*North Carolina Hooded* is a hooded barley well suited to North Carolina conditions. At present this variety is grown on about 3,500 acres.

With the expansion of barley growing in North Carolina, a number of types have evolved; one of the best of these is the North Carolina Hooded. This designation may include a number of barleys, or at least a barley that is not wholly uniform.

The *Oderbrucker* barleys as known at present are six-rowed, rough-awned varieties with white kernels. They are particularly prized by maltsters in the upper Mississippi Valley. They yield well and are stiff-strawed and moderately tolerant to summer heat and humidity. Oderbrucker selections were grown on 1,024,000 acres in 1935.

Oderbrucker was originally a variety identical with or similar to the Manchuria. As with the latter variety, it consisted of a large number of strains, both blue and white. A report in the old Government records of 1865 states: "This variety is grown very extensively on the low, formerly swampy lands of the Valley of the Oder, but which were drained during the reign of Frederick the Great." An importation by the Federal Government apparently never reached the farmers. In 1889, however, the Ontario Agricultural College at Guelph received this barley from Germany and later sent it to the Wisconsin Agricultural Experiment Station. It was widely distributed by the Wisconsin Station and most of the improvement was made at that place. In 1908 R. A. Moore and A. L. Stone of Madison released Wisconsin Pedigree 5 and Wisconsin Pedigree 6. Both of these were selections of Oderbrucker. They constitute the entire Oderbrucker acreage today.

*Odessa* is similar to Manchuria in many ways. It is rough-awned and six-rowed, with kernels about the same size as Manchuria. It is even more tolerant to summer heat and probably to drought. It is particularly adapted to eastern South Dakota, where it yields well. It is estimated that it was grown on 955,000 acres in 1935, almost all of which were in South Dakota.

Odessa was grown in the test plats at Ottawa, Canada, in 1890. It was obviously an importation from south Russia. It was obtained from Ottawa in 1902 by the United States Department of Agriculture and later sent to a number of experiment stations. The South Dakota Station tested it thoroughly and released it to farmers in 1914.

The *Oklahoma Winter* barley is peculiarly adapted to Oklahoma, Missouri, southwestern Kansas, and the Texas Panhandle. It is six-rowed, rough-awned, and moderately winter-hardy. It was grown on about 120,000 acres in 1935. Oklahoma Winter is the result of natural evolution. Tennessee Winter, Michigan Winter, and even some of the northern spring types were brought into Oklahoma for fall seeding. Gradually a type emerged which differs from any of these in the nature of its cold resistance. It is more tolerant to the dry cold of that section than is Tennessee Winter. On the other hand it is not as winter-hardy as Tennessee Winter when grown in Virginia. Oklahoma Winter is probably the result of natural selection in a mixed variety.

*O. A. C. 7* is a six-rowed, rough-awned, white-kernelled variety which gives high yields in western Oregon, where it can be seeded either in the fall or in early spring. It is grown on slightly more than 9,000 acres, all in western Oregon.

The variety originated as a plant selection made by G. R. Hyslop from Webb's New Hardy White Winter. It was distributed from the Oregon Agricultural Experiment Station in 1909.

*O. A. C. 1* and *6* are six-rowed, rough-awned, white barleys of the Tennessee Winter type. No. 1 is apparently somewhat more winter-hardy than no. 6. The commercial acreage is small.

E. N. Bressman, when with the Oregon Station, selected some of the surviving plants of Tennessee Winter following an unusually cold winter at Corvallis. The progeny of two of these were distributed in 1925 as *O. A. C. 1* and *O. A. C. 6*.

*Orel* is a two-rowed, rough-awned, white-kerneled winter barley. It yields well and has a good straw and very long heads, but is only moderately winter-hardy. It can be seeded in the spring if seeded early. There is a nominal acreage in Virginia.

*Orel* was secured by the United States Department of Agriculture from Russia in 1904 through L. L. Bolley of North Dakota. A selection of *Orel* was released in 1925 from the Arlington Experiment Farm, Rosslyn, Va., by J. W. Taylor. The original importation, grown at Aberdeen, Idaho, has assumed a habit quite different from that of the variety as grown at Arlington. Probably the variety was not pure for all characters and natural selection has resulted in a different type.

*Peatland* is a six-rowed, rough-awned, stiff-strawed sort, resistant to spot blotch, root rot, and black stem rust, and moderately resistant to scab. It was grown on about 2,300 acres in Minnesota in 1935.

It was produced by H. K. Hayes and H. V. Harlan in the cooperative work between the Minnesota Agricultural Experiment Station and the United States Department of Agriculture. It is a selection of a barley from Canton Lucerne, Switzerland, which was presented to the United States Department of Agriculture by Albert Vollhart of Zurich. The Swiss barley was an unimproved variety containing many types. *Peatland* was released to farmers in 1926.

*Sacramento* is a dense, stiff-strawed, six-rowed, rough-awned, blue variety resistant to smut and mildew. It is not commercially important, probably due to its lateness.

It was produced by W. W. Mackie of the California Agricultural Experiment Station from a hybrid of Cape  $\times$  Coast.

*Spartan* is a two-rowed, smooth-awned, early variety with an unusually stiff straw. It is grown on about 128,000 acres, mostly in Michigan and Nebraska.

It was selected from a hybrid, Michigan two-row  $\times$  Black Barless, which was made by E. E. Down and H. M. Brown. It was released to farmers in 1918.

*Stavropol* is a rough-awned, six-rowed, blue-kerneled barley closely related to Coast. It is grown on about 200,000 acres, mostly in Kansas, where it yields well and is resistant to drought.

This variety was doubtless brought into western Kansas by the Russian immigrants. A similar barley, however, was obtained by M. A. Carleton of the United States Department of Agriculture from near Stavropol, Russia, in August 1900.

*Tennessee Beardless 5* and *6* are hooded winter sorts adapted to the southern winter barley section. It is estimated that they were grown on 35,000 acres in 1935. Most of the acreage is in North Carolina, Tennessee, and Missouri.

They were produced by C. A. Mooers of the Tennessee Agricultural Experiment Station, who crossed Tennessee Winter on a hooded spring barley, probably of the Horsford type. Professor Mooers released them to farmers in 1915.

*Tennessee Winter* is the most vigorous and most widely adapted of our winter barleys. It is a rough-awned, six-rowed variety, the kernels of which are similar to Manchuria in both size and character. The variety is not pure and local changes have taken place in widely separated sections. It is annually grown on about 210,000 acres in our Southern States, from Maryland to Oklahoma.

Its origin is not known, but at some time it probably came into the South from Switzerland or the Balkans. The variety Union Winter and the Kentucky local barley are likely of the same stock. The lot released from the Tennessee station as Tennessee Winter has been most widely grown.

*Tennessee Winter 52*. This selection of Tennessee Winter is similar to the parent variety but has unusual stooling capacity and yields well. It is susceptible to smut.

H. V. Harlan made a considerable number of selections of winter barley in the fields of Tennessee and Kentucky. Curiosity led to the inclusion of no. 52 in more elaborate tests because, although it was highly susceptible to smut at Rosslyn, Va., it produced high yields. It was distributed to a number of places, and Mooers found its stooling capacity and yielding qualities to outweigh its moderate susceptibility to smut at Knoxville.

*Tennessee Winter Texas 12576*. This selection of Tennessee Winter has broader leaves and a shorter but larger head, and the grain is earlier in maturity and less dormant than the typical Tennessee Winter. It produces high yields in Texas, where it is grown on 121,000 acres.

The variety was produced by mass selection from Tennessee Winter by A. H. Leidigh and C. H. McDowell at the Denton (Tex.) station. It was released in 1918.

*Tennessee Winter Texas 643-33* is a selection of Tennessee Winter. It is winter-hardy and yields well. It is now grown on about 10,000 acres.

The selection was made and tested by A. H. Leidigh and P. B. Dunkle. It was released in 1924.

*Trebi* is a barley of exceptional vigor. It yields well even in sections where it appears to be too late to escape heat damage and to be too susceptible to disease injury for the best results. It is grown from Minnesota to Nevada. It is six-rowed and rough-awned and has large blue kernels. As grown in the upper Mississippi Valley, it is not desired by the maltsters, but produces large amounts of feed grain. Under irrigation in the Rocky Mountain region, the quality is better and it has produced large yields. One farm yield of 131 bushels per acre is reported under irrigation. Trebi was grown on 2,224,000 acres in 1935, the largest acreage of any single variety.

A barley from the south side of the Black Sea was secured by the United States Department of Agriculture in 1905. It was grown in cooperation with the Minnesota Agricultural Experiment Station in 1909. H. V. Harlan isolated a number of distinct types in that year. In 1913 they were sent to Aberdeen, Idaho, where they were tested in cooperation with the University of Idaho. Trebi was released from Aberdeen in 1918.

*Union Beardless* is a hooded, naked, six-rowed variety. It is leafy, erect, and prized for hay. It is adapted to the irrigated valleys of eastern Oregon. It was grown on 12,000 acres in 1935, all in Oregon.

Union Beardless was produced by Robert Withecombe by hybridization at the Union branch station. It was released in 1910.

*Vaughn* is the most vigorous six-rowed, smooth-awned barley grown on the Pacific coast. It produces very high yields, is stiff strawed, and early. The hull, however, frays, and consequently this variety is not wanted by maltsters or barley rollers. It was grown on about 7,000 acres in California and Arizona in 1935.

Vaughn came from a hybrid of Lion  $\times$  Club Mariout. The hybrid was made by H. V. Harlan in the greenhouse at Rosslyn, Va., in the winter of 1912-13. The first and second generations were grown at the University of Minnesota in the cooperative work with the United States Department of Agriculture. Vaughn was selected from the hybrid population and sent to Moro, Ore., in 1916. It was included in the nursery at Davis, Calif., in 1922. Its first-yield test at that place was made under the supervision of V. H. Florell in 1924 in the cooperative work of the California Agricultural Experiment Station and the United States Department of Agriculture. The variety was released in 1926.

*Velvet* is a smooth-awned, six-rowed hybrid with white kernels. The hull is better than that of some of the smooth-awned sorts. The variety produces high yields of grain of good malting quality. It is resistant to spot blotch and root rot. It was grown on 1,726,000 acres in 1935, the second largest acreage of any single variety.

Velvet is a product of the cooperative work of the Minnesota Agricultural Experiment Station and the United States Department of Agriculture. Manchuria was crossed on Lion in the Washington (D. C.) greenhouse by H. V. Harlan in the winter of 1912-13. Smooth-awned segregates were isolated from this cross in the cooperative work at the Minnesota Station. None of these seemed superior, and at the request of H. K. Hayes one of the segregates was crossed on Luth (a Manchuria selection) by Harlan in 1917. As a matter of convenience this cross was made at Aberdeen, Idaho, and to save time the  $F_1$  was grown in the greenhouse at Rosslyn, Va., in 1917. This made it possible to grow the  $F_2$  in Minnesota in 1918. Subsequent generations were grown at St. Paul, Minn., in a special disease nursery by the plant genetic and plant pathology sections of the university. Velvet was selected under these conditions. H. K. Hayes, F. Griffec, E. C. Stakman, and J. J. Christensen played an important part in these tests. The variety was released in 1926.

*White Smyrna* is two-rowed, semirough-awned and white. It is a low-growing sort, the spike of which is often only partially exerted from the boot. It is large-kernelled, drought-resistant, and early. It was grown on 170,000 acres in 1935, mostly in South Dakota and Colorado.

Smyrna was first received by the United States Department of Agriculture in 1901 through George C. Roeding of Fresno, Calif., who obtained it from B. J.

Agadjanian of Smyrna. It was sent to many experiment stations and the date it was released to farmers is not known.

*Winter Club* is a dense, six-rowed, white barley of moderate winter hardiness. It will grow from spring seeding if seeded early. It is stiff-strawed and yields well in the Great Basin and the Pacific Northwest. It was grown on about 19,000 acres in 1935, mostly in Washington, Idaho, and Utah.

The variety is old in North America and its history is not known. The first sample received by the Department came from George A. Smith of Lewiston, Idaho, in 1903. A record of 1907 from Nephi, Utah, states that the barley had been grown there for 35 years and was probably introduced from California. It was extensively grown in Utah before it was displaced by Trebi.

*Wisconsin Pedigree 37* and *38* are smooth-awned, white, six-rowed varieties. They have good straw, are resistant to stripe, and produce high yields of grain of good malting quality. They are popular and were grown on 873,000 acres in 1935. *Wisconsin Pedigree 38* seems to be the better of the two and most of the acreage is of that variety.

Both varieties were produced by B. D. Leith of the Wisconsin Agricultural Experiment Station. They came from a cross of *Wisconsin 5* and *Lion*. *Wisconsin 5* is an *Oderbrucker*. The varieties were released in 1929-30.

*Wisconsin Winter* is a rough-awned, six-rowed variety adapted to fall seeding in the southeastern winter barley area. It is early and yields well. Its present acreage is nominal.

The origin of the parent barley is not known, but it probably came from the Balkans. It was first secured by the United States Department of Agriculture in 1905 from Texas. The Texas correspondent stated that he secured it from La Crosse, Wis., in 1898. The present variety came from a selection made by J. W. Taylor at the Arlington Experiment Farm at Rosslyn, Va. This selection was released in 1922.

TABLE 1.—*Present objectives of barley breeders at United States experiment station.*

[Yield is omitted as all breeders are working to secure higher yielding varieties]

Location of station	Resistance to -													
	Smooth awns	Hoods	Naked	Quality	Stiff straw	Winter hardiness	Earliness	Cold resistance	Tillering	Nonshattering	Forage	Covered smut	Loose smut	Stripe ( <i>Helminthosporium graminum</i> )
California, Davis	+	+	+				+					+		
Colorado, Fort Collins	+	+		+										
Georgia, Experiment	+	+		+										
Idaho, Aberdeen	+	+		+	+	+		+	+	+				
Idaho, Moscow	+	+		+	+									
Illinois, Urbana	+	+		+	+				+					
Indiana, Lafayette	+					+								
Iowa, Ames	+			+	+									
Kentucky, Lexington	+	+												
Maryland, College Park	+					+								
Michigan, E. Lansing	+			+	+	+								
Minnesota, St. Paul				+	+	+						+		
Missouri, Columbia		+				+	+				+			
Montana, Bozeman	+		+	+	+					+				
Montana, Moccasin				+	+									
New Jersey, New Brunswick	+			+	+				+	+				
New Mexico, State College	+													
New York, Ithaca	+											+	+	
North Carolina, Raleigh		+										+	+	
North Dakota, Fargo				+										
Ohio, Columbus and Wooster	+			+										
Oklahoma, Stillwater						+	+							
Oklahoma, Woodward						+	+							
Oregon, Eastern	+	+		+	+					+		+		
Oregon, Western	+			+	+		+							
South Dakota, Brookings				+	+									
Tennessee, Knoxville									+					
Texas, Denton	+					+						+	+	
Utah, Logan	+				+	+							+	
Virginia, Rosslyn	+													
Washington, Pullman	+	+		+	+									
Wisconsin, Madison	+											+		

TABLE 2.—*Past and present workers in the United States who have devoted or are devoting part or all of their time to barley improvement*

[An asterisk (\*) designates workers all or part of whose salaries are paid from Federal funds]

Location of workers	Early workers	Present workers
Washington, D. C.....	H. B. Derr,* S. A. Anthony,* Albert Mann.*	H. V. Harlan,* G. A. Wiebe,* M. N. Pope,* Mary L. Mar- tini,* and Lucille Reinbach.*
Arizona, Tucson.....		A. T. Bartel.*
Arkansas, Fayetteville.....		C. K. McClelland.
California, Davis.....	G. W. Shaw, G. W. Hendry, W. W. Mackie, V. H. Florell,* and G. A. Wiebe.*	F. N. Briggs and C. A. Suneson.*
Colorado, Akron.....		J. J. Curtis.*
Colorado, Fort Collins.....	D. W. Frear and G. W. Deming...	D. W. Robertson, Dwight W. Koonce, and Dean C. Ander- son.
Georgia, Experiment.....		R. P. Bledsoe and S. J. Hadden.*
Idaho, Aberdeen.....	L. C. Aicher* and G. A. Wiebe.*	Harland Stevens* and John L. Toevs.
Idaho, Moscow.....	V. H. Florell*	C. A. Michels and W. M. Bever.*
Illinois, Urbana.....		O. T. Bonnett.
Indiana, Purdue.....		R. R. Mulvey and G. H. Cutler.
Iowa, Ames.....		L. C. Burnett* and J. B. Wentz.
Kansas, Hays.....		A. F. Swanson.*
Kansas, Manhattan.....		J. H. Parker.*
Kentucky, Lexington.....		E. J. Kinney.
Maryland, College Park.....		R. G. Rothgeb and W. B. Kemp.
Michigan, East Lansing.....	F. A. Spragg.	J. W. Thayer, Jr., and F. E. Down.
Minnesota, St. Paul.....	Willet M. Hays, H. K. Hayes, E. C. Stakman, F. J. Steven- son, LeRoy Powers, and C. P. Bull.	J. J. Christensen and F. R. Immer.
Missouri, Columbia.....	C. A. Helm.....	E. M. Brown.
Montana: Bozeman.....	LeRoy Powers, J. E. Norton, and Austin Goth.	L. P. Reitz.
Havre.....		M. A. Bell.
Moccasin.....	E. L. Adams,* N. C. Donaldson,* and R. W. May.*	J. L. Sutherland.*
New Jersey, New Brunswick.....		R. E. Blaser, G. W. Burton, M. E. Paddick, and H. B. Sprague.
New Mexico, State College.....	W. T. Conway.....	J. C. Overpeck and Glen Staten.
New York, Ithaca.....		F. P. Russell, W. T. Craig,* and H. H. Love.
North Carolina, State College Station.....		G. K. Middleton.
North Dakota: Fargo.....	T. E. Stoa and L. R. Waldron.	
Dickinson.....		R. W. Smith.*
Mandan.....		J. C. Brinsmade, Jr.*
Ohio, Columbus and Wooster.....		L. E. Thatcher and J. B. Park.
Oklahoma: Stillwater.....		C. B. Cross.
Woodward.....	Edmund Stephens*.....	V. C. Hubbard.*
Oregon: Burns.....		Obil Shattuck.
Corvallis.....	G. R. Hyslop, C. C. Ruth, and E. N. Bressman.	D. D. Hill.
Moro.....		D. E. Stephens.*
Pendleton.....		J. F. Martin.*
Union.....	Robert Withycombe.....	D. E. Richards.
South Dakota, Brookings.....	A. N. Hume, Manley Champlin, and E. S. McFadden.*	K. H. Klages.
Tennessee, Knoxville.....	C. A. Mooers.....	H. P. Ogden and Newman Han- cock.
Texas: College Station.....	A. H. Leidigh.....	P. C. Mangelsdorf.
Denton.....	C. H. McDowell.....	I. M. Atkins* and P. B. Dunkle.
Utah, Logan.....	George Stewart.....	R. W. Woodward* and D. C. Tingey.
Virginia, Arlington Experimental Farm.....		V. F. Tapke* and J. W. Taylor.*
Washington, Pullman.....		E. F. Gaines, O. E. Barbee, E. G. Schaefer, and O. A. Vogel.*
West Virginia, Morgantown.....		J. S. Bennett, and R. J. Garber.
Wisconsin, Madison.....	R. A. Moore and A. L. Stone.....	B. D. Leith, H. L. Shands, J. G. Dickson,* R. G. Shands,* and A. D. Dickson.*
Wyoming, Laramie.....	B. C. Buffum, D. W. Robertson, and J. C. Overpeck.	Glen Hartman, A. F. Vass, and G. H. Starr.

## A Partial List of Past and Present Barley Breeders in Foreign Countries

*Names of Those Who Have Published Major Papers on Barley Breeding and the Places at Which Some of Their Work Was Done*

- |   |  |
|---|--|
| Bakhteyev, F., Leningrad, Union of Soviet Socialist Republics.          | Lorenz, E., Kloster, Gerode, Germany.                                  |
| Barbacki, S., Pulawy, Poland.   | McRostie, G. P., Winnipeg, Manitoba, Canada.                           |
| Beaven, E. S., Warminster, England.                                     | Miege, E., Rabat, Morocco.   |
| Benes, V., Brunn, Czechoslovakia.                                       | Miyake, K., Tokyo, Japan.  |
| Berg, S. O., Landskrona, Sweden.  | Miyazawa, B., Miyazaki, Japan.   |
| Bezradecki, S., Pulawy, Poland.   | Neathy, K. W., Winnipeg, Manitoba, Canada.                             |
| Biffin, R. H., Cambridge, England.                                      | Newman, L. H., Ottawa, Ontario, Canada.                                |
| Bjannes, ———, Moistad, Hjellum, Norway.                                 | Nicolaisen, W., Halle, Germany.  |
| Blaringhem, L., Paris, France.  | Nilsson, N. H., Svalof, Sweden.  |
| Boeuf, F., Tunis, Tunisia.  | Nilsson-Ehle, H., Svalof, Sweden.                                      |
| Browne, F. S., Lennoxville, Quebec, Canada.                             | Orlov, A. A., Leningrad, Union of Soviet Socialist Republics.          |
| Carne, W. M., Merridin, West Australia.                                 | Peitel, M. J., Derbent, Dagestan, Union of Soviet Socialist Republics. |
| Champlin, M., Saskatoon, Saskatchewan, Canada.                          | Peterson, R. F., Brandon, Manitoba, Canada.                            |
| Clark, J. A., Charlottetown, Prince Edward Island, Canada.              | Proskowetz, E. von, Kvasice, Moravia.                                  |
| Colin, P., Ottawa, Ontario, Canada.                                     | Regel, R., Leningrad, Union of Soviet Socialist Republics.             |
| Cowan, P. R., Ottawa, Ontario, Canada.                                  | Rigo, G., Minsk, Union of Soviet Socialist Republics.                  |
| Ducellier, L., Algiers, Algeria.  | Rocmer, T. E., Halle, Germany.   |
| Eikeland, Voll, Moholton, Norway.                                       | Saunders, C. E., Ottawa, Ontario, Canada.                              |
| Engledow, F. L., Cambridge, England.                                    | Scharnagel, T., Freising, Germany.                                     |
| Fjaervoll, K., Holt, Tromso, Norway.                                    | Schiemann, Eliz., Berlin, Dahlem, Germany.                             |
| Foss, H., Token, Volbu, Norway.   | Sigfusson, S., Brandon, Manitoba, Canada.                              |
| Freistedt, P., Halle, Germany.  | Squirrel, W., Guelph, Ontario, Canada.                                 |
| Hallquist, C., Landskrona, Sweden.                                      | Summerby, R., MacDonald College, Quebec, Canada.                       |
| Harrington, J. B., Saskatoon, Saskatchewan, Canada.                     | Takezaki, Y., Kyoto, Japan.  |
| Huber, J. A., Freising, Germany.  | Tedin, H., Svalof, Sweden.   |
| Hunter, H., Cambridge, England.   | Tedin, O., Landskrona, Sweden.   |
| Ikeno, S., Tokyo, Japan.  | Tinney, B. J., Charlottetown, Prince Edward Island, Canada.            |
| Imai, Y., Tokyo, Japan.   | Tschermak, E., Vienna, Austria.  |
| Jakowski, Z., Poznan, Poland.   | Ubisch, G. von, Heidelberg, Germany.                                   |
| Kajanus, B., Landskrona, Sweden.  | Vavilov, N. I., Leningrad, Union of Soviet Socialist Republics.        |
| Karpechenko, George D., Leningrad, Union of Soviet Socialist Republics. | Veideman, M., Leningrad, Union of Soviet Socialist Republics.          |
| Kiessling, L., München, Germany.  | Vestergaard, H. A. B., Sollested, Denmark.                             |
| Kuckuck, H., Müncheberg, Germany.                                       | Vik, K., Aas, Norway.  |
| Kwen, S., Kaifeng, Honan, China.  | Wenholz, H., Sydney, Australia.  |
| Lamprocht, H. A. K., Landskrona, Sweden.                                | Wexelsen, H., Hjellum, Norway.   |
| Larionow, D. K., Kozin, Union of Soviet Socialist Republics.            | Zavitz, C. A., Guelph, Ontario, Canada.                                |
| Laumont, P., Algiers, Algeria.  |  |
| Lewicki, S., Pulawy, Poland.  |  |
| Linland, ———, Forus, Norway.  |  |
| Lods, Emile, MacDonald College, Quebec, Canada.                         |  |

TABLE 3.—Genetic studies in barley in the United States

State and cross	By whom made	Year	Character and ratio	Linkage cross-overs (percent)
California: Numerous crosses (parent varieties not given).	K. S. Hor-----	1924	Wide—narrow outer glumes, 3:1; rough—smooth awn, 3:1; long—short-haired rachilla, 3:1; hulled—naked, 3:1; general—restricted pubescence of outer glumes, 3:1; black—white lemma, 3:1; hood—awn, 3:1; extended—normal outer glume, 1:2:1; dwarf—normal, 3:1; 6-row—non-6-row, 3:1; and 2-row—deficiens, 3:1.	Naked kernel with restricted pubescence of outer glume, 25.3; black lemma with long-haired rachilla, 41.0; smooth awn with long-haired rachilla, 31.6; black lemma with smooth awn, 38.4; and 6-row with extended outer glumes, 40.5.
Chevalier X Abyssinian.	W. W. Mackie----	1928	Resistance—susceptibility to rusty blotch, 3 resistant: 1 susceptible.	
Numerous crosses (parent varieties not given).	G. F. H. Buckley----	1930	Red—white pericarp, 2 factors; <i>Ir</i> factor gave 3:1, purple—white lemma, <i>Pp</i> 3:1; purple—white-veined lemma, 3 factors; <i>Cc</i> factor, 3:1; blue—white aleurone, <i>B/b</i> 3:1; 6-row—2-row, <i>a/a'</i> 3:1; long-haired—short-haired rachilla, <i>L/l</i> 3:1; hood—awn, <i>Kk</i> 3:1; hulled—naked, <i>Nm</i> 3:1; straight—curved peduncle, <i>Cr cr</i> 3:1; black—white lemma, <i>Bb bB</i> 3:1; white—orange lemma, <i>Br br</i> 3:1; normal—albino seedling, <i>Alb<sup>+</sup> alb<sup>-</sup></i> 3:1; complementary genes <i>R</i> and <i>J</i> in dominant forms inhibit the expression of <i>R</i> and <i>P</i> .	Purple-veined lemma with purple lemma, 34.34; purple-veined lemma with red pericarp, 33.73; 6-row with purple-veined lemma, 22.19; 6-row with red pericarp, 16.86; 6-row with purple lemma, 19.38; red pericarp with purple lemma, 0.47; long-haired rachilla with red pericarp, 34.65; long-haired rachilla with orange lemma, 39.11; and hoods with blue aleurone, 40.56.
Manchuria X Deficiens.	G. A. Wiebe-----	1934	Complementary factors give lethal progeny.	
Atlas X Hanna-----	F. N. Briggs-----	1935	Resistance—susceptibility to mildew, 3:1; susceptibility incompletely dominant.	
Colorado: Coast X Hooded-----	Kezer and Boyack----	1918	Hoods—awn, 3:1-----	White with xantha seedlings, 4.0.
Coast X Black Hulled.	-----do-----	1918	Hoods—awn, 3:1; black glume—white glume, 3:1; and 2-row—6-row, 3:1.	Do.
Colless I X Colless IV.	D. W. Robertson----	1929	Green—white seedlings ( <i>A<sub>1</sub>a<sub>1</sub></i> ), 3:1; green—xantha seedlings ( <i>X<sub>1</sub>x<sub>1</sub></i> ), 3:1.	Do.
Colless I X <i>distichon nigrinudum</i> . Colless I X Minnesota 90-5. Colless I X Minnesota 90-8. Colless I X Minnesota 90-5. Colless I X Minnesota 90-8.	-----do-----	1929	Black glume—white glume ( <i>Bb</i> ), 3:1; hoods—awns ( <i>Kk</i> ), 3:1; covered—naked seed ( <i>Nn</i> ), 3:1. Long-haired to short-haired rachilla ( <i>Ss</i> ), 3:1; black glume—white glume ( <i>Bb</i> ), 3:1; hoods—awns ( <i>Kk</i> ), 3:1.	Black glume with hoods, independent. Black glume with covered, independent. Hoods with covered, independent. Long-haired rachilla with hoods, independent. Long-haired rachilla with black glume, independent.
Colless I X <i>II. deficiens nudideficiens</i> .	-----do-----	1929	Long-haired to short-haired rachilla ( <i>Ss</i> ), 3:1; covered—naked ( <i>Nn</i> ), 3:1; non-6-row; 6-row ( <i>Vv</i> ), 3:1.	Long-haired rachilla with covered, independent; covered with non-6-row, independent.
Colless I X <i>II. distichon nigrinudum</i> .	-----do-----	1929	Non-6-row to 6-row ( <i>Vv</i> ), 3:1; hoods—awns ( <i>Kk</i> ), 3:1; black—white; glume color ( <i>Bb</i> ), 3:1.	6-row with hoods, independent; 6-row with black glume, independent.
Trebi X Minnesota 90-5.	-----do-----	1929	Black—white ( <i>Bb</i> ), 3:1; seedlings green—white ( <i>A<sub>1</sub>a<sub>1</sub></i> ), 3:1.	White glume; white seedlings, 22.29.
Colless I X <i>II. distichon nigrinudum</i> ; Colless I X Minnesota 90-5; Colless I X Minnesota 90-8.	-----do-----	1929	Green—white; seedlings ( <i>A<sub>1</sub>a<sub>1</sub></i> ), 3:1; black—white glume; color ( <i>Bb</i> ), 3:1; hoods—awns ( <i>Kk</i> ), 3:1.	White glume; white seedling, independent; hoods with white seedlings, independent.

TABLE 3.—*Genetic studies in barley in the United States—Continued*

State and cross	By whom made	Year	Character and ratio	Linkage cross-overs (percent)
Colorado—Con. Colse ss I X Minne- sota 90-8; Col- se ss I X Minne- sota 90-8.	D. W. Robertson.	1929	Green—white seedlings ( $A_{a_2}$ ), 3:1; long-haired to short-haired rachilla ( $Ss$ ), 3:1.	White seedlings with long-haired rachilla, independent.
Colse ss I X <i>H. distichon nigrinudum</i> ; Colse ss I X <i>H. deficiens nudideficiens</i> .	do.	1929	Green—white seedlings ( $A_{a_2}$ ), 3:1; covered- naked seeds ( $Nn$ ), 3:1.	White seedlings with covered seeds, independent.
Colse ss I X <i>H. distichon nigrinudum</i> .	do.	1929	Green—white seedlings ( $A_{a_2}$ ), 3:1; non-6-row to 6-row ( $Vv$ ), 3:1.	White seedlings with 6-row, independent.
Colse ss I X Colse ss IV.	do.	1929	Green—white seedlings ( $A_{a_2}$ ), 3:1; green—xantha seedlings ( $Xx$ ), 3:1.	White seedlings with xantha seedlings, 4.0.
Colse ss I X Colse ss V.	do.	1930	Green—white seedlings ( $A_{a_2}$ ), 3:1; green—chlorina seedlings ( $Ff$ ), 3:1.	White seedlings with chlorina seedlings, independent.
Trebi X Colse ss V.	do.	1930	Green—white seedlings ( $A_{a_2}$ ), 3:1; green—chlorina seedlings ( $Ff$ ), 3:1.	Do.
Coast I X Colse ss V.	do.	1930	Green—xantha seedlings ( $Xx$ ), 3:1; green—chlorina seedlings ( $Ff$ ), 3:1.	Xantha seedlings with chlorina seedlings, independent.
Coast II X Colse ss V.	do.	1930	Green—white seedlings ( $A_{a_2}$ ), 3:1; green—chlorina seedlings ( $Ff$ ), 3:1.	White seedlings with chlorina seedlings, independent.
Colse ss I X Coast I.	do.	1930	Green—white seedlings ( $A_{a_2}$ ), 3:1; green—xantha seedlings ( $Xx$ ), 3:1.	White seedlings with xantha seedlings, independent.
Colse ss IV X Coast III.	do.	1930	Green—xantha seedlings ( $Xx$ ), 3:1; green—virescent seedlings ( $Yy$ ), 3:1.	Xantha seedlings with virescent seedlings, independent.
Colse ss I X Coast I.	do.	1930	Green—xantha seedlings ( $Xx$ ), 3:1; hoods—awns ( $Kk$ ), 3:1.	Xantha with hoods, independent.
Colse ss IV X Coast III.	do.	1930	Green—virescent seedlings ( $Yy$ ), 3:1; hoods—awns ( $Kk$ ), 3:1.	Virescent with hoods, independent.
Coast X Colse ss V.	do.	1930	Green—chlorina seedlings ( $Ff$ ), 3:1; hoods—awns ( $Kk$ ), 3:1.	Chlorina with hoods independent.
Coast X Lion.	do.	1930	Branched—unbranched style 63:1; $G.g., G'g', G''g'$ .	
Trebi X Minne- sota 84-7.	D. W. Robertson, G. W. Deming, and D. Koonce.	1932	Green—white seedlings ( $A_{a_2}$ ), 3:1; green—chlorina seedlings ( $Ff$ ), 3:1.	White seedlings with chlorina, independent.
Colse ss I X Min- nesota 84-7.	do.	1932	Green—white seedlings ( $A_{a_2}$ ), 3:1; green—chlorina seedlings ( $Ff$ ), 3:1.	Do.
Coast III X Colse ss V.	do.	1932	Green—virescent seedlings ( $Yy$ ), 3:1; green—chlorina seedlings ( $Ff$ ), 3:1.	Virescent seedlings with chlorina, 29.3.
Colse ss V X Min- nesota 84-7.	do.	1932	Green—chlorina seedlings ( $Ff$ ), 3:1; green—chlorina seedlings ( $Ff$ ), 3:1.	Chlorina seedlings with chlorina seedlings, independent.
Colse ss I X Min- nesota 84-7.	do.	1932	Green—chlorina seedlings ( $Ff$ ), 3:1; long-haired to short-haired rachilla ( $Ss$ ), 3:1.	Chlorina seedlings with long-haired rachilla, independent.
Minnesota 84-7 X Trebi.	do.	1932	Green—chlorina seedlings ( $Ff$ ), 3:1; non-6-row to 6-row.	Chlorina seedlings with non-6-row, $18.3 \pm 0.74$ .
Colse ss X Minne- sota 84-7.	do.	1932	Green—chlorina seedlings ( $Ff$ ), 3:1; hoods—awns ( $Kk$ ), 3:1.	Chlorina seedlings with hoods, independent.
Colse ss IV X Min- nesota 72-8.	do.	1932	Green—xantha seedlings, ( $Xx$ ), 3:1; blue-white aleurone, ( $Bl. bl.$ ), 3:1.	Xantha seedlings with blue aleurone, independent.
Colse ss V X Nepal.	do.	1932	Green—chlorina seedlings ( $Ff$ ), 3:1; long-haired to short-haired rachilla ( $Ss$ ), 3:1.	Chlorina seedlings with long-haired rachilla, independent.
Colse ss X Minne- sota 72-8.	do.	1932	Hoods—awns ( $Kk$ ), 3:1; blue-white aleurone ( $Bl. bl.$ ), 3:1.	Hoods with blue aleu- rone, $22.58 \pm 0.82$ .
Do.	do.	1932	Blue-white aleurone ( $Bl. bl.$ ), 3:1; long-haired to short-haired rachilla ( $Ss$ ), 3:1.	Blue aleurone with long- haired rachilla, inde- pendent.



TABLE 3.—*Genetic studies in barley in the United States*—Continued

State and cross	By whom made	Year	Character and ratio	Linkage cross-overs (percent)
Colorado—Con. Coast X Lion-----	D. W. Robertson, G. W. Deming, and D. Koonce.	1932	Black—white glume ( <i>Bb</i> ), 3:1; rough—smooth awn <i>R. r.</i> , <i>R.' r.'</i> , 12:3:1.	Black with rough awn, independent.
Do-----	do-----	1932	Black—white glume ( <i>Bb</i> ), 3:1; branched—unbranched styles, <i>G. g.</i> , <i>G.' g.'</i> , <i>G'' g''</i> , 63:1.	Black glume with branched style, inde- pendent.
Do-----	do-----	1932	Long-haired to short-haired rachilla ( <i>Ss</i> ), 3:1; rough— smooth awned, <i>R. r.</i> , <i>R.'</i> <i>r'</i> , 12:3:1.	Long with rough awn ( <i>Rr.</i> ), 34.63±1.76.
Do-----	do-----	1932	Rough—smooth awn ( <i>Hr.</i> , <i>R.' r.'</i> ), 12:3:1; branched— unbranched style <i>Gg.</i> , <i>G'</i> <i>g'</i> , <i>G'' g''</i> , 63:1.	Rough with branched style, indication of linkage.
Colsess V X Nepal.	D. W. Robertson.	1933	Green—chlorina ( <i>Fefc</i> ), 3:1; covered—naked seed ( <i>Nn.</i> ), 3:1.	Chlorina seedlings with naked, independent.
Colsess V X Che- valier.	do-----	1933	Green—chlorina ( <i>Fefc</i> ), 3:1; intermedium—noninter- medium ( <i>H.</i> ), 3:1.	Chlorina seedlings with intermedium, inde- pendent.
Do-----	do-----	1933	Intermedium—noninterme- dium ( <i>H.</i> ), 3:1; hoods— awns ( <i>Kk.</i> ), 3:1.	Intermedium with hoods 15.12±0.65.
Colsess X Black Hullless.	do-----	1933	Green—white seedlings ( <i>Aa</i> ), 3:1; hoods—awns ( <i>Kk.</i> ), 3:1.	White seedlings with hoods, independent.
Do-----	do-----	1933	Covered—naked seeds ( <i>Nn.</i> ), 3:1.	White seedlings with naked seeds, inde- pendent.
Do-----	do-----	1933	Long-haired to short-haired rachilla ( <i>Ss.</i> ), 3:1.	White seedlings with naked seeds, 26.
Trebi X Nilsson— Ehle No. 2.	do-----	1933	Non-6-row to 6-row ( <i>Vv</i> ), 3:1; purple—white straw color ( <i>Pr. pr.</i> ), 3:1; inter- medium—noninterme- dium ( <i>H.</i> ), 3:1.	6-row with purple straw, 9.0±0.68; intermedium with purple straw, inde- pendent.
Illinois: Wisconsin Pedigree No. 5 X Spartan.	O. T. Bonnett-----	1929	Tillering—number of tillers not directly controlled by genes; early—late, 3:1; 2-row—6-row, 1:2:1.	
Iowa: Velvet X Trebi-----	J. B. Wentz-----	1928	Smooth awns—barbed awns, 13:3.	
Glabron X Trebi-----	do-----	1928	do-----	
Minnesota: Manchuria X Svanhals and Pyramidatum X Jet.	H. K. Hayes and H. V. Harlan.	1920	Long internode in rachis versus short internode in rachis (1-factor pair dif- ference + modifying fac- tors).	
Hanna X Reid's Triumph.	do-----	-----	Long internode in rachis versus short internode in rachis (2-factor pair dif- ference + modifying fac- tors).	
Hanna X Zeocriton.	H. K. Hayes and and H. V. Harlan.	1920	Long internode in rachis versus short internode in rachis (3-factor pairs + modifying factors).	
Manchuria X Svan- hals.	do-----	1920	Vulgate versus intermedium versus distichon (2-factor pairs + modifying factors).	
Lion X Manchuria.	H. K. Hayes, E. C. Stakman, Fred Griffec, and J. J. Chris- tensen.	1923	Rough versus smooth awn (1-factor pair X modifying factors); black versus white color of glumes (1-factor pair); resistance versus susceptibility to <i>Helmintho- sporium sativum</i> (2-factor pairs).	
Svanhals X Lion-----	Fred Griffec-----	1925	Rough versus smooth type of awn (2-factor pairs).	
Do-----	do-----	1925	Non-6-rowed versus 6-rowed ( <i>VE</i> ) ( <i>ve</i> ) ( <i>Vv</i> ) and early heading versus late head- ing ( <i>Ee</i> ).	42
			Rough versus smooth awn and resistance to <i>H. sati- vum</i> versus susceptibility.	Rough and resistance. Smooth and susceptibil- ity correlation.

TABLE 3.—*Genetic studies in barley in the United States*—Continued

State and cross	By whom made	Year	Character and ratio	Linkage cross-overs (percent)
Minnesota—Con. Svanhals × Lions..	Fred Griffee.....	1925	Black versus white color of glume and resistance to <i>H. sativum</i> versus susceptibility.	Black and susceptible, white and resistance correlation.
B17 was crossed with B1, B3, and B11.	Adrian Daane.....	1931	Normal, virescent seedling ( <i>Aa</i> ) ( <i>AV</i> ) ( <i>av</i> ). Non-6-rowed versus 6-rowed ( <i>Vv</i> ) ( <i>AP</i> ) ( <i>ap</i> ). Black versus white glume color ( <i>Bb</i> ) ( <i>Rs</i> ) ( <i>rs</i> ). Hooded versus awned ( <i>Kk</i> ); rough versus smooth awn ( <i>Rr</i> ); covered versus naked caryopsis ( <i>Nn</i> ); long versus short-haired rachilla ( <i>Ss</i> ); purple versus white pericarp ( <i>Pp</i> ).	28. 18. 28.
Pentland × Glabron.	LeRoy Powers and Lee Hines.	1933	Resistance to <i>Puccinia graminis tritici</i> physiologic forms nos. 17, 38, and 49 versus susceptibility to these organisms ( <i>Tt</i> ).	
New York: 2-rowed × 6-rowed.	F. P. Russell.....	1921 and later.	2-6, 9:7	
Hulled × Hull-less.	do.....		Hulled—hull-less, 3:1	
Pubescence × nonpubescence.	do.....		Pubescence—nonpubescence, 3:1	
Articulation of rachis × nonarticulation.			Articulated—nonarticulated, 63:1	
Colored × non-colored flowering glumes.			Colored—noncolored, 3:1	
Hooded × awned.			Hoods—awns, 3:1	
Awned × awnless.			Awned—awnless, 15:1	
Ohio: Olds White Hull-less (hooded) × Arlington awnless.	L. E. Thatcher....	1916	F <sub>1</sub> intermediate-sized hoods; F <sub>2</sub> , a graded series ranging from long awns to very short awns and from no lemma appendages through short spurs to large hoods. Interpreted as a dihybrid with incomplete dominance giving 6 fairly distinct phenotypes and 9 genotypes. A dominant factor <i>H</i> for hoods; recessive <i>h</i> produces awns: <i>1th</i> , intermediate awns; dominant inhibitor <i>I</i> strongly suppresses and <i>i</i> partially suppresses <i>I</i> and <i>h</i> .	
Wisconsin: Wisconsin Pedigree 5 × Leiorhynchum.	B. D. Leith.....	1917	Black—white, 3:1; rough—smooth, 3:1.	

TABLE 4.—*Barley varieties: Estimated acreage and recommended varieties, by States*

[Acreage estimated in percentage by State and Federal officials, and computed on the July 1935 forecast by the Division of Crop and Livestock Estimates, Bureau of Agricultural Economics. Varieties the acreage of which is increasing are indicated by +, those decreasing by —]

State	Varieties grown	Hundred acres	Varieties recommended
Arizona.....	Coast..... Beardless..... Vaughn..... Hannchen..... Trebi.....	—264 19 +15 +6 6	Vaughn. Coast.
California.....	Atlas..... Club Mariout..... Coast.....	—6,501 2,128 +1,182	Atlas. Club Mariout.

TABLE 4.—*Barley varieties: Estimated acreage and recommended varieties, by States—Continued*

State	Varieties grown	Hundred acres	Varieties recommended
California	Tennessee Winter.....	+1,182	
	Hero.....	+591	
	California 4000.....	118	
	California Mariout.....	59	
	Vaughn.....	59	
Colorado	Trebi.....	-1,850	Trebi, irrigated.
	Coast, Smyrna, etc.....	-1,517	Velvet, irrigated.
	Colsess.....	185	Colsess, irrigated.
	Velvet.....	+74	
	Club Mariout.....	+74	Club Mariout, dry land.
	Vance Smyrna.....		Flynn, dry land.
	Flynn.....		Vance Smyrna, dry land.
Idaho	Trebi.....	+1,392	Trebi.
	Coast.....	-139	Hannchen.
	Hooded.....	70	Winter Club.
	Hannchen.....	69	
	Winter Club.....	35	
	Eastern types.....	35	
Illinois	Velvet.....	-276	Wisconsin Pedigree 38.
	Oderbrucker.....	-180	Velvet.
	Wisconsin Pedigree 37 and 38.....	+120	
	Trebi, Spartan, etc.....	24	
Indiana	Oderbrucker.....	98	Wisconsin Pedigree 38.
	Wisconsin Pedigree.....	+84	Velvet.
	Spartan.....	+42	
	Velvet.....	+42	
	Tennessee Winter.....	14	
Iowa	Velvet.....	-4,633	Do.
	Manchuria.....	-832	Trebi.
	Glabron.....	+178	
	Trebi.....	-178	
	Wisconsin Pedigree 37 and 38.....	119	
Kansas	Stavropol.....	1,855	Stavropol.
	Coast.....	445	Manchuria.
	Trebi.....	371	Odessa.
	Winter.....	371	Oderbrucker.
	Odessa.....	+185	
	Manchuria.....	+185	
	Oderbrucker.....	+148	
	Hooded.....	148	
Kentucky	Tennessee and Union Winter.....	126	Tennessee Winter.
	Kentucky 1.....	+11	Kentucky 1.
	Tennessee Beardless.....	3	
Maine	Manchuria & Oderbrucker.....	30	
	Alpha, Wisconsin Pedigree 38, and Velvet.....	30	
Maryland	Tennessee Winter.....	+204	Tennessee Winter.
	Other varieties, mostly hooded.....	6	No barb.
Michigan	Spartan.....	-940	Spartan.
	Oderbrucker.....	620	Wisconsin Pedigree 38.
	Wisconsin Pedigree 38.....	+282	
	Michigan Winter.....	19	
	Black Barbless.....	-19	
Minnesota	Velvet.....	+6,912	Velvet.
	Minnesota 184.....	-6,682	Minnesota 184.
	Glabron.....	4,608	Trebi.
	Trebi.....	-4,378	Peatland.
	Peatland.....	+230	Glabron.
	Others.....	230	Wisconsin Pedigree 38.
Missouri	Tennessee Winter.....	+240	Missouri Early Beardless.
	Oklahoma Winter.....	+200	Kentucky 1.
	Tennessee Beardless 5 and 6.....	100	Tennessee Beardless 5.
	Velvet.....	25	
	Oderbrucker.....	25	
	Manchuria.....	25	
	Trebi.....	25	
	Missouri Early Beardless.....	+10	
	Kentucky 1.....	+10	
Montana	Trebi.....	-1,104	Trebi, irrigated.
	Horn and Hannchen.....	460	Horn, dry land.
	Oderbrucker, Wisconsin Pedigree 38, Velvet, and Manchuria.....	+147	
	Faust and Himalaya.....	111	
	Others.....	18	
Nebraska	Trebi.....	+1,996	Trebi.
	Mixed.....	1,640	Glabron.
	Short Comfort.....	+1,212	Spartan.
	Glabron.....	+998	Short Comfort.
	Velvet.....	571	Tall Comfort.
	Tall Comfort.....	-428	Velvet.
	Spartan.....	+285	

TABLE 4.—*Barley varieties: Estimated acreage and recommended varieties, by States—Continued*

State	Varities grown	Hundred acres	Varities recommended
Nevada	Coast	30	Coast.
	Trebi	30	Trebi.
New Jersey	Velvet	+4	Velvet.
	Winter	+4	
	Alpha, Bon Ami, etc	-2	
New Mexico	Coast	70	C. I. 4673.
	Unidentified	30	Coast.
	Others	20	
New York	Alpha	1,376	Alpha.
	Wisconsin Pedigree 38	+172	Wisconsin Pedigree 38.
	Other smooth-awned	138	
	Featherston	-34	
North Carolina	Tennessee Beardless 6	84	Tennessee Beardless 6
	North Carolina Hooded	35	North Carolina Hooded.
	Bearded	21	
North Dakota	Manchuria-Oderbrucker+mixtures	-8,330	Manchuria.
	Trebi	5,950	Trebi.
	Manchuria-Oderbrucker	4,760	Oderbrucker.
	Wisconsin Pedigree 38	2,350	Wisconsin Pedigree 38.
	Miscellaneous	1,666	Velvet.
	Velvet	714	
Ohio	do	+128	Do.
	Oderbrucker	-34	
	Winter Barley	+8	
Oklahoma	Oklahoma and Tennessee Winter	825	Oklahoma Winter.
	Manchuria and Oderbrucker	110	
	Coast and others	165	
Oregon (eastern)	Trebi	247	Trebi.
	Miscellaneous	166	Winter Club.
	Club Mariout	124	Flynn.
	Union Beardless	123	
	Meloy	82	
	Hannchen	82	
Oregon (western)	do	384	O. A. C. 7.
	O. A. C. 7	93	Hannchen.
	Others	22	
	Wisconsin Pedigree 38	16	
	Trebi	16	
	Tennessee Winter	11	
	Chevalier	6	
Pennsylvania	Alpha	200	Alpha.
	Wisconsin Pedigree 38	160	Wisconsin Pedigree 38.
	Tennessee Winter	150	Tennessee Winter.
	Tall Comfort	109	Tall Comfort.
South Dakota	Odessa	+9,368	Odessa.
	Trebi	+3,513	Velvet.
	Velvet	+2,342	Wisconsin Pedigree 38.
	Glabron	+2,342	Glabron.
	Others, mostly Manchuria	-2,342	Trebi.
	Ace	-1,171	Horn.
	White Smyrna	-1,171	White Smyrna.
	Wisconsin Pedigree 38	+703	Ace.
	Horn	-468	
Tennessee	Tennessee Beardless 5 and 6	128	Tennessee Beardless 5 and 6.
	Tennessee Winter and Union Winter	42	Union Winter.
			Tennessee 52.
Texas	Tennessee Winter 12,576	+1,212	Tennessee Winter, 12,576.
	Tennessee Winter	-606	Tennessee Winter 643-33.
	Tennessee Winter 643-33	101	
	Others	101	
Utah	Trebi	428	Trebi.
	Utah Winter and others	22	Utah Winter.
Virginia	Union Winter and Tennessee Winter	+256	Tennessee Winter.
	Awnless	61	Union Winter.
	Tennessee Beardless 6	23	
Washington	Beldi Giant	+272	Beldi Giant.
	Blue	-136	Horsford.
	White Winter	-136	White Winter.
	Horsford	+102	
	Others	34	
West Virginia	Tennessee Winter	+32	
	Smooth-awned and hooded winters	+6	
	Manchuria, Oderbrucker, and Alpha	2	
Wisconsin	Wisconsin Pedigree 38	4,630	Wisconsin Pedigree 38.
	Oderbrucker	+3,241	
	Velvet, etc	+1,389	
Wyoming	Trebi	+742	Trebi, irrigated.
	Horn	228	Horn, dry land.
	Hannchen	20	Odessa, Coast.